A

TEXT BOOK

OF

HUMAN ANATOMY

FOR THE USE OF STUDENTS.

TRANSLATED BY

OWEN LANKESTER, M.R.C.S.

WITH FIFTY-ONE ANATOMICAL ILLUSTRATIONS IN THE TEXT, AND FOUR FULL-PAGE PLATES PRINTED IN COLOURS.

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Editor B.M.J.

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HUMAN ANATOMY

FOR THE USE OF STUDENTS.

Specially prepared to accompany the Set of Anatomical Diagrams by DRS. FIEDLER & HOELEMANN.

TRANSLATED AND ADAPTED FOR ENGLISH USE

BY

OWEN LANKESTER, M.R.C.S.,

Hon. Assoc. Order of St. John of Jerusalem, Lecturer and Examiner to the National Health Society.

WITH FIFTY-ONE ANATOMICAL ILLUSTRATIONS IN THE TEXT, AND FOUR FULL-PAGE PLATES PRINTED IN COLOURS.

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FIRST PART.

THE BONY SYSTEM.

I.—The Bones in General.

THE skeleton supplies by its strength the necessary support to our bodies, and provides cavities for the protection of a large number of important internal organs (heart, lungs, brain, &c.); the bones also serve as points of attachment and support to the muscles and other soft parts. They are joined to each other by tendinous cords and bands in many places, so that they are able to move in harmony with, or opposition to, each other in many different ways (Joints).

Kinds of bones.

The bones are divided into: long or cylindrical bones; flat bones; short bones.

The *long bones* are tubular (for example, the upper arm and thigh bones), and consist of two thickened ends covered with cartilage (articular ends), and an intermediate cylindrical part, the shaft. This latter is compact and strong on the outside (the compact substance), and porous, and filled with blood-vessels and marrow, on the inside (spongy substance). The articular ends also consist of an outer compact layer and an inner spongy mass.

The *flat bones* are those which go to form the bony cavities; among them are the skull, the pelvic bones, the breast bone, &c.

The *short bones* are small, and have a rounded or cubical appearance, like the vertebræ, and small bones of the hand and foot.

Component parts of bone.

The bone as a whole consists of: periosteum, bone substance, marrow.

The Periosteum is a thin, pale red, tendinous membrane, rich in blood-vessels, and firmly adherent to the surface of the bones (except at the articular ends).*

The bone substance is of a yellowish colour, and consists of a mixture of several materials, among which may be especially mentioned:

* A large number of vessels from the periosteum run into the pores in the bone substance for purposes of nourishment, branch up in it, and reach the central marrow. After an injury to the periosteum the underlying bone either becomes diseased or dies (caries or necrosis). After injuries new bone is formed from the periosteum. In healthy people the bone and periosteum are not very sensitive, but inflammation of them causes the most severe pain, and generally leads to very tedious illnesses.

1. The earthy matter* (bone earth), a strong calcareous mass which gives the bones their hardness and strength, and enables them to keep their shape for many years, even after death.† Eventually bone crumbles into dust and earth. If the bones are steeped for a few days in hydrochloric acid, the calcareous parts are dissolved, the cartilaginous substance remains behind; the bone retains its shape, but is soft, elastic, and easily bent.

2. The cartilage, a soft gristly mass which unites the earthy constituents together. If bone be strongly heated, the cartilage is burnt away; the bone still retains its outward form, but it is dry and brittle, and at the slightest blow falls into dust. If bone is boiled the cartilage is changed into glue.

If the cartilaginous matter be removed from bone, there appear in the latter an immense number of small holes which were formerly

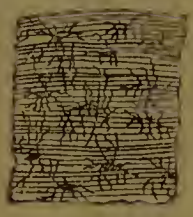


Fig. 1 *a*. Bone Corpuscles (magnified by about 150).

Fig. 1 *b* Longitudinal Section of Bone. *a*. Haversian or bone canals. *b*. Bone corpuscles.

filled with the cartilaginous substance. On making a microscopic examination of thin sections of bone, it can be seen that the bony mass is penetrated by the finest spaces and canals (Bone corpuscles and canaliculi).‡ These are in communication with the blood vessels of the periosteum, they contain an albuminous fluid, and carry on the nutrition of the bone.‖ (Figs. 1 *a* and 1 *b*.)

* It consists in the main of about 50 parts of phosphate of lime, 10 parts of carbonate of lime, and 1 part of other saline matters.

† The best evidence of the power of resistance which bones possess against external agencies is afforded by the preservation of the bones of pre-Adamite animals.

‡ In order to examine bone microscopically a flat piece is ground down on a fine whetstone till it is quite thin and transparent.

‖ The earthy matter of bone varies in amount with age, so that it forms in early youth about $\frac{1}{2}$, in middle life about $\frac{2}{3}$, in old age about $\frac{5}{6}$ of bone. Fractures of bone occur therefore more frequently in the aged than in children. In the latter curvatures are frequently seen, especially of the legs; the soft matter is present to an abnormal extent in Rickets.

A fracture of bone unites in such a way that a coagulating fluid is poured out from

The marrow is a fatty yellowish-red substance full of blood-vessels found in the interior of bone in the spongy portion.

The bones, in their natural positions and union by means of cartilage, tendons, and ligaments, form a strong frame called the *skeleton*. The skeleton of an adult human being weighs about thirteen to sixteen pounds.

Cartilage.

Cartilage* is of a blue-white colour, softer, but more elastic and pliable, than bone. It is found as a covering to the articular ends of bones to protect them from pressure and friction; it also forms the ground substance of those parts which must possess a certain form, but yet be at the same time pliable and movable, as the ear, nose, larynx, air-tubes, &c.

In old age, cartilage has a great tendency to ossify or turn into bone. By boiling it is changed into a kind of glue or jelly. Like bone, cartilage is covered with a membrane rich in blood-vessels, from which its nourishment is derived. Under the microscope, cells are also seen in it, embedded either in an apparently structureless or fibrous ground-substance (fig. 2).

Fig. 2. Cartilage Corpuscles (× 150).

Bones are united to each other by means of—

Joints,† as in the long bones.

Suture, that is by toothed surfaces fitting into each other, as in the flat bones of the skull;

Cartilage, as in the union of the ribs with the breast-bone.

In the first kind of union the joint is more or less movable; in the last two kinds there is little or no movement.

Joints.

The following are the main differences between the various kinds of joints:—

1. Hinge joints, like the knee and elbow. Plate I.

The bones which are bound together to form the joint can move on

the periosteum, which becomes cartilaginous (callus) and finally ossifies. The ends of the bone are thereby firmly united together. When a fracture is set the broken ends are brought as close together as possible, and the bones put in their proper position and direction.

* In new-born children most bones still consist entirely of cartilage.

† If the joint surfaces lose their state of apposition, as sometimes happens after an injury, a dislocation or luxation is said to occur. By a sprain we mean a stretching or tearing of the capsule of the joint, or of the surrounding ligaments, caused by violence. As a rule this is accompanied by rupture of blood-vessels; blood is poured out under the skin and into the soft parts around the joint; these become swollen and appear purple.

one another in one plane only; they form, when bent, an angle, when extended a straight line.

2. Free or ball-and-socket joints, which allow of free movement, as in the shoulder and hip joints.

There are other joints in which the bones can only move on one another to a very limited extent, as in the small bones of the hand and foot. Others, again, allow of rotation only, as in the radius in the fore-arm around the elbow.

Over the contiguous joints-ends the capsule is stretched like a bag, which secretes on its inner surface a slimy substance, the *synovial fluid*.* The object of this is to afford easy movement, and to abolish friction between the bones. The joint capsule has a great tendency to inflammation, as, for instance, in rheumatism of the joint, &c. The capsule is more or less tense, and is, as a rule, strengthened on its outer surface by strong ligamentous bands. It is strongly united to the periosteum above and below the joint.

In the suture joint the toothed edges of the flat bones of the skull overlap and interlock. The sutures completely disappear in after years by growing together and ossification.

The number of bones amounts to 213, not counting the 32 teeth; 33 of them are in the middle line, 90 are on each side and are paired.

II.—The Skeleton.

Plate I. Figure 3.

It is convenient to divide the bones of the body into those of the head, trunk, and limbs.

I. Bones of the Head. (I. 1 to 8.)

Bones of the head.

All the bones of the head are immovable, and for the most part flat; only the lower jaw can be moved. Their main use is to form the cavities of the skull:

The *cranial* bones for the brain and organs of hearing.

The *facial* bones for the organs of sense (eye, nose, and mouth).

The number of bones in the head is 22; they are divided into eight cranial and 14 facial bones.†

* In inflammation of a joint the synovial fluid is secreted very copiously, it is of a thin fluid character and distends the capsule. The joint is then very painful. In rheumatism many joints are often inflamed at the same time.

† The size and shape of the face and cranial bones vary with different people; by this means different races can be distinguished. The cranial bones have openings of different sizes through which blood-vessels and nerves run.

PLATE I.

1. Frontal bone.
2. Parietal bone.
3. Temporal bone.
4. Superior maxillary bone (upper jaw).
5. Malar bone (cheek bone).
6. Lacrimal bone.
7. Inferior maxillary bone (lower jaw).
8. Nasal bone.
9. Cervical vertebræ (seven in number, forming neck).
10. Dorsal vertebræ (twelve in number, to which ribs are attached).
11. Lumbar vertebræ (five in number).
12. Sacrum (composed of five vertebræ joined together).
13. Coccyx (composed of four vertebræ joined together). In animals this bone forms the tail.
14. Sternum, or breast bone.
15. Ribs (twelve in number).
15*a*. Cartilaginous portion of the ribs.

16*a*. Ilium
16*b*. Ischium
16*c*. Pubes
} These three portions together form the os innominatum, or nameless bone. The two nameless bones with the sacrum form the *pelvis*.

17. Clavicle or collar-bone.
18. Scapula or shoulder-blade.
19. Humerus or arm-bone.
20. Radius, outer side.
21. Ulna, inner side.
} Bones of forearm.
22. Carpal bones (eight in number, forming wrist).
23. Metacarpal bones (five in number, forming hand proper).
24. Phalanges (three for each finger, forming fingers).
25. Femur or *thigh*-bone.
26. Tibia or shin-bone, inside.
27. Fibula, outside.
} Bones of leg proper.
28. Patella, or knee cap.
29. Tarsal bones (seven in number).
30. Metatarsal bones (five in number).
31. Phalanges (three for each toe, two for great toe).

Fig. 3.

The cranial cavity is formed, among others, by—

The frontal bone, in front.

The occipital bone, behind.

The temporal bones, one on each side.

The parietal bones, one on each side.*

Fig. 4. Bones of the Skull and Face from below.

a. Foramen magnum for the spinal cord. *b*. Occipital bone. *c*. Sutures. *d*. Basal part of the occipital bone. *e e*. Articular surface of the first cervical vertebra (Atlas). *f f*. Mastoid process of the temporal bone. *g*. Foramen for the jugular vein. *h*. The styloid process of the temporal bone. *i*. The vomer. *k k*. The zygomatic arch. *l l*. The palate bone. *m m*. Palate process of the superior maxilla. *n n*. Posterior entrance to the nares. *o o*. Wings of the sphenoid. *p*. Incisor teeth. *q q*. Canine teeth. *r r*. Anterior molar teeth. *s s*. Posterior molar teeth. *t t*. Wisdom teeth. *u*. Pterygoid process of the sphenoid.

Of the facial bones the most important† are :—

The *superior maxillary bones*, which carry the upper teeth.

The *malar* and *zygomatic bones* (I. 5) which unite on both sides with the lower outer borders of the frontal bone, and with the upper

* The temporal bones lie in front of the auditory canal and behind the eye ; they are partly covered and protected by the curved zygomatic bone, and partly uncovered. The uncovered part of the bone is very thin, and injuries of the skull in this region are very dangerous. At the base of the skull are the sphenoid and ethmoid.

† The inner, deeper-lying bones of the skull and face, not visible from without, are of secondary importance from our present point of view, and only a brief mention of them is made.

outer border of the superior maxillary bone, are extended in a curved manner over the temporal bones and pass behind the ear; the prominence between the eye and ear is caused by them.

The *nasal bones* (I. 8).—These start from the middle of the lower edge of the frontal bones, and form the strong upper part of the nose; the lower part of the nose has a cartilaginous basis.

The Lower Jaw (I. 7).—The lower teeth are seated in this bone. It is somewhat like a horse-shoe, and, on account of the shape of its joint, possesses a considerable amount of movement to allow of mastication. The teeth are firmly wedged into sixteen hollows or sockets.

Variation of the cranial bones with age.

The cranial bones in the early years of life have wide gaps between them filled with cartilage (Fontanelles), and on this account easily permit of a considerable growth of brain substance; in consequence of the softness and yielding nature of the skull in the child, injuries and blows on it may have serious results.*

Complete growth of the cranial bones is attained at about the twentieth year; if growth is completed earlier, the full development of the brain is interfered with.†

II. The Bones of the Trunk. (Fig. 5.)

Bones of the trunk.

In consequence of their natural arrangement these can be divided into—

a. Bones of the spinal column.
b. ,, thorax (ribs and breast-bone).
c. ,, pelvis.

* The *Sphenoid* (IV. *o o*) forms a great part of the base of the skull, and consists of a cubical middle part, the Body (situated in about the middle of the head). From it six bony processes, with complicated branches, arise; they are called wings of the sphenoid.

The *Vomer* (IV. *i*) forms the posterior part of the nasal septum, and divides the nasal cavity into two halves.

The *Palate* (IV. *l l*) forms the posterior part of the arch of the mouth cavity.

The *Lacrimal bone* (I. 6), the smallest of all the bones of the head, lies at the inner angle of the orbit.

The *Ethmoid* lies under the frontal bone, between the two orbits, and behind the nasal bone. It takes its name, which means sieve, from an immense number of little holes, through which the branches of the nerve of smell (olfactory nerve) enter the nose.

The *Turbinated bones* form convoluted bony surfaces inside the nose, and are covered by the nasal mucous membrane.

† By an accumulation of fluid in the cavities of the brain, as happens in certain forms of inflammation of the brain in children, the bones, being not yet united, are forced asunder; the skull thereby often acquires quite a remarkable circumference, and a condition known as "water on the brain" is set up.

Spinal column.

The spinal column from before, backwards, is a slightly curved arch, which contains in its interior a canal for the reception of the spinal marrow; it is made up of 24 separate bones (vertebræ), joined together by ligamentous bands and discs of cartilage.

Vertebræ.

In the vertebræ themselves the following parts are distinguished :— An anterior disc-like part, the Body (Fig. 9), and several tubercles or processes, directed upwards, downwards, sideways, and backwards.*

The sacrum (I. 12) is joined to the spinal column below; it is formed by the union of five separate vertebræ, which unite the spinal column with the pelvic bones.

The coccyx (I. 13) is attached to the lowest part of the sacrum; it is the termination of the spinal column, and consists of several small round bones capable of slight movement.

Kinds of vertebræ.

Vertebræ of the Neck (Cervical), I. 9. (Fig. 6.)

These, seven in number, form the uppermost part of the spinal column; being the smallest and thinnest of all, they possess comparatively free movement in almost all directions.

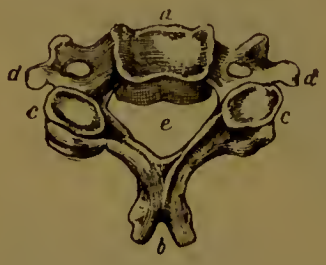


Fig. 6. Cervical Vertebra.

a. Body. *b*. Spinous process. *c*. Articular surface. *d*. Transverse process, with opening for the vertebral arteries. *e*. Foramen for the spinal cord.

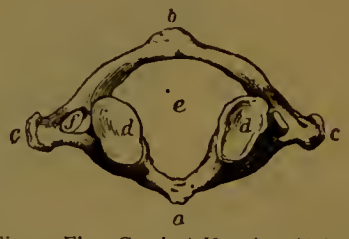


Fig. 7. First Cervical Vertebra (Atlas).

a. Anterior arch. *b*. Posterior arch. *c*. Transverse process. *d*. Articular surface. *e*. Foramen for spinal cord. *f*. Foramen for the vertebral arteries.

The first cervical vertebra on which the head rests is called the Atlas (Fig. 7). It has on its upper surface two laterally-placed cup-like articular surfaces, which allow the head to move forwards and backwards on a horizontal axis (nodding movement). The atlas has no body; it consists in the main of two bony arches (see woodcut); on its under surface it has two pan-like articular surfaces.

The second cervical vertebra is called the Axis (Fig. 8). This carries on its anterior arch a vertical peg about 1½ cm. long, the Odontoid

* These serve partly as points of attachment for muscles; being also supplied with articular surfaces, they allow of a certain amount of movement between the separate vertebræ in different directions.

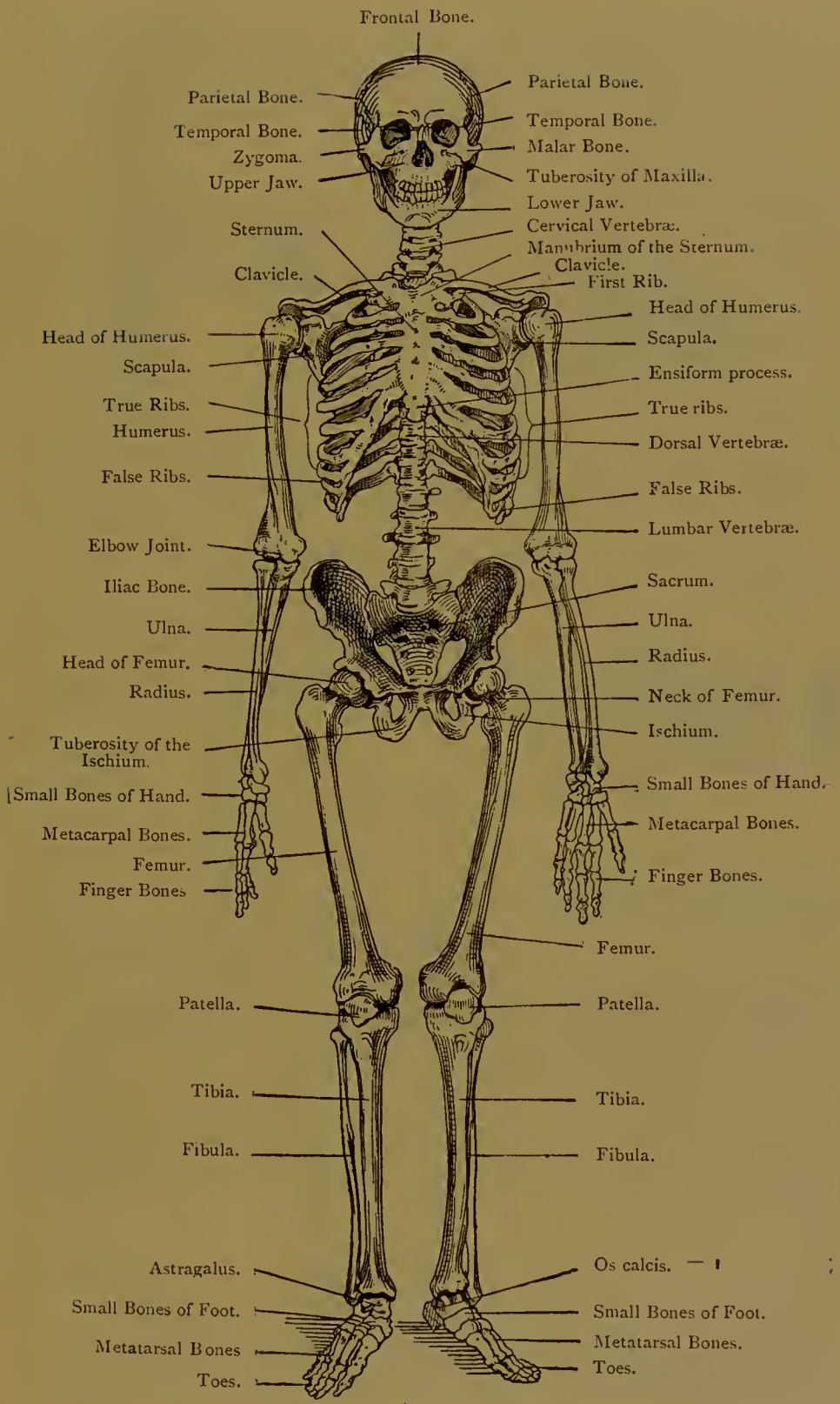

Frontal Bone.
Parietal Bone.
Parietal Bone.
Temporal Bone.
Temporal Bone.
Zygoma.
Malar Bone.
Upper Jaw.
Tuberosity of Maxilla.
Lower Jaw.
Sternum.
Cervical Vertebræ.
Manubrium of the Sternum.
Clavicle.
Clavicle.
First Rib.
Head of Humerus.
Head of Humerus.
Scapula.
Scapula.
Ensiform process.
True Ribs.
True ribs.
Humerus.
Dorsal Vertebræ.
False Ribs.
False Ribs.
Lumbar Vertebræ.
Elbow Joint.
Sacrum.
Iliac Bone.
Ulna.
Ulna.
Radius.
Head of Femur.
Radius.
Neck of Femur.
Ischium.
Tuberosity of the Ischium.
Small Bones of Hand.
Small Bones of Hand.
Metacarpal Bones.
Metacarpal Bones.
Femur.
Finger Bones.
Finger Bones
Femur.
Patella.
Patella.
Tibia.
Tibia.
Fibula.
Fibula.
Astragalus.
Os calcis.
Small Bones of Foot.
Small Bones of Foot.
Metatarsal Bones
Metatarsal Bones.
Toes.
Toes.

Fig. 5.

process. This is kept in position against the anterior arch of the Atlas by a strong band shaped like a cross, the cruciform ligament. By means of the joint between the first and second vertebræ, a turning of the head from side to side, to the extent of half a circle, is allowed.

Fig. 8. Second Cervical Vertebra (Axis).
a. Body. *b*. Odontoid process. *c*. Articular surfaces. *d*. Transverse process.

Fig. 9. Dorsal Vertebra.
a. Body. *b*. Spinous process. *c*. and *d*. Depressions for the ribs on the transverse process. *e*. Upper articular process. *f*. Lower articular process.

The *dorsal vertebræ* (I. 10, Fig. 9). These are larger than the last. On their sides are surfaces to which the ribs are jointed.*

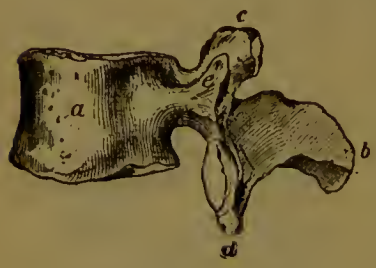


Fig. 10. Lumbar Vertebra.
a. Body. *b*. Spinous process. c. Upper articular process. *d*. Lower articular process. *e*. Transverse process.

The *lumbar vertebræ* (I. 11, Fig. 10). These are the largest and thickest of the vertebræ; the height of the bodies of the vertebræ increases from above downwards continuously, so that the cervical vertebræ have the smallest, the lumbar vertebræ the largest bodies.

Union of the vertebræ.

On the anterior and posterior surfaces of the vertebral column between the processes of the vertebræ are ligamentous bands which run the whole length of the column.

These join the vertebræ together and protect the column and spinal cord from excessive bending and other movements,

Between the vertebral bodies are very strong, flat, fibrous, intervertebral discs, which form an intimate union between the vertebræ, and also by their elasticity are able to diminish the effect of injuries inflicted on the column in a vertical direction (like the buffers of a railway carriage).†

* The appearance of the different kinds of vertebræ can be recognised by the adjoining woodcuts.

† In old age the intervertebral discs partly disappear; the vertebræ come closer together; the spinal column, and consequently the man, are somewhat shorter.

By a fall or blow on the spine, as well as by inflammation of the vertebræ, a remarkable curvature of the spine is sometimes produced (the person appears hunchbacked).

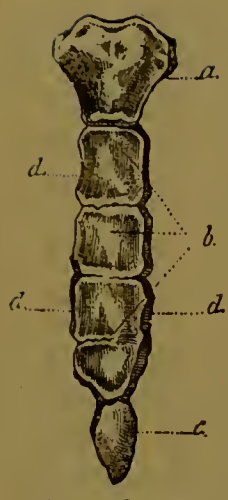


Fig. 11. Sternum.
a. Handle or manubrium. b. Body. c. Ensiform process. d. Attachment of rib cartilege.

Thorax.

The *chest* or *thorax* is formed by the sternum or breastbone, the ribs, and by some of the vertebræ (dorsal).

Sternum.

The *sternum* (I. 14, Fig. 11), is a flat, sword-shaped bone situated in the front of the chest; it consists of an upper wide part, the *handle* or manubrium, a middle, somewhat prominent part, the *body*, and a lower generally cartilaginous part below, the *ensiform* process.

On the right and left sides of the manubrium the curved clavicles are placed, which stretch towards the shoulder, also the two uppermost ribs; on the body of the sternum the upper true ribs are seated.

The *ensiform* process, 5–7 cm. long and somewhat movable, ends between the muscles at the pit of the stomach.

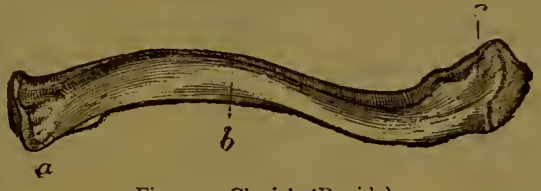


Fig. 12. Clavicle (R. side).

a. The inner or sternal end is united with the handle of the breast-bone. *b*. Shaft of the clavicle. *c*. Outer or scapular end.

Ribs.

The *ribs* are attached, twelve on each side, to the dorsal vertebræ. The true ribs increase from above downwards in length but diminish in curvature. The chest thereby has the shape of a cone, considerably wider below than above.

Fig 13. True Rib.
a. Head. b. Neck. c. Body.

Form and purpose of the ribs.

The ribs are long, flat, curved bones, they unite the spinal column to the sternum, and form a protecting lattice to the contents of the chest (heart, lungs, &c.).

The *true* ribs are the seven upper pairs, which are joined to the sternum by short cartilages, and form the side walls of the chest.

The *false* ribs, the five lower pairs, do not reach the sternum, but are united by cartilage with each other and with the lowest true ribs.

But this union does not take place with the two last pairs of ribs, which have free ends, and consequently possess a considerable range of movement.

The spaces between the ribs are filled with flat muscles. Partly by means of these, and partly by the muscles of the neck, which are attached to the upper ribs, the chest is capable of a certain amount of movement, which is seen during breathing in the rise and fall of the chest. Blood-vessels and nerves, protected from injury as far as possible, lie between the ribs.*

Touching the chest-wall are the two clavicles and the two shoulder-blades, one on each side.†

The Clavicle.

The clavicles bound the thoracic cavity at its upper part. At their inner ends they are attached near the middle line to the sternum; they pass straight outwards with a slight S-shaped curve to one of the processes of the shoulder-blades. They form the anterior part of the shoulder girdle, and serve as protecting arches over the large blood-vessels, nerves, &c., which pass from the thoracic cavity to the neck and head.

The shoulder blades.

The shoulder-blades, or scapulæ, are smooth, flat, triangular bones, the apex being downwards; they lie on either side of the vertebral column at the posterior upper part of the thorax, close under the skin, and are held fast by the pressure of the air and by muscles.

Their position changes with movements of the arms, as they possess articular surfaces at their anterior part for the upper arm.

The pelvis.

The pelvis consists of the two innominate bones, the sacrum and coccyx, it forms a very strong, complete, bony ring, wide at the posterior part and from side to side, but smaller in front; it is much narrowed at its lower part, and limited behind by the sacrum. The upper wide part is called the false pelvis, the lower narrower part the true pelvis.

In youth the innominate bones consist of six separate bones, which become joined together in later years.‡

On the outer side of the innominate bone there is a cup-shaped depression, the glenoid cavity, for articulation with the thigh-bone.

* In youth the bones of the chest, like all bones, are especially flexible. By faulty and negligent carriage of the body, by long-continued pressure on the chest, such as it is subject to in writing, and in certain trades, like shoemaking, a slight persistent curvature of the spine and narrowing of the whole cavity of the chest may ensue. By a straight position in sitting, walking, and standing, by deep inspiration, by properly directed gymnastics, &c., the simultaneous development of the chest and of its contained organs, as well as of the whole body, is substantially brought about.

† In addition, the clavicles act as a stay to the shoulder, like a buttress. As the ribs and clavicles are thin, and only slightly protected by soft parts, fractures of them are frequent.

‡ Each innominate bone consists of an iliac bone, whose upper border can be felt beneath the skin on each side, the ischium and pubes.

The innominate bone serves as the chief point of attachment for the legs (lower extremities), and also forms the lower limit for the

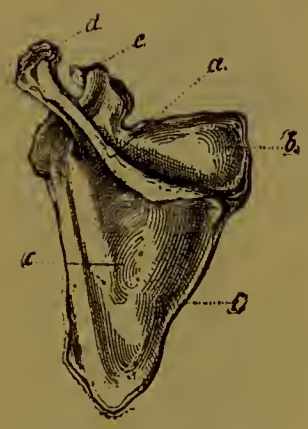


Fig. 14. Left Scapula.

a. Spine. *b*. Supra spinous fossa. *c*. Infra spinous fossa. *d*. Acromion process. *e*. Coracoid process. . Base of the scapula.

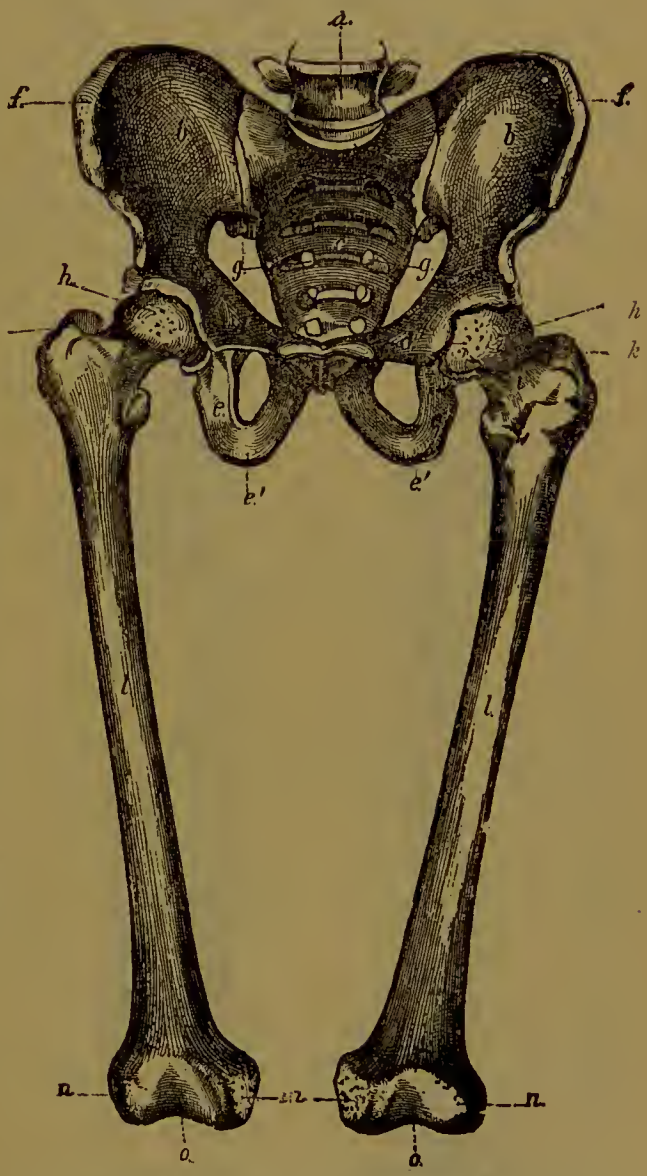


Fig. 15. The Pelvis and Thigh Bones.

a. Last lumbar vertebra. *bb*. Iliac bones. *c*. Sacrum. *dd*. Pubes. *ee*. Ischium. *e'e'*. Tuberosity of ischium. *ff*. Crest of the ilium. *gg*. Entrance for spinal nerves. *hh*. Head of femur. *ii*. Neck of femur. *kk*. Greater tuberosity of the femur. *ll*. Shaft of femur. *m*. Inner condyle of femur. *nn*. Outer condyle. *o*. Articular surface for the patella.

abdominal cavity. It forms a strong support for the intestines and abdominal organs.

The Bones of the Limbs or Extremities.

Bones of the limbs.

The bones of the limbs, arms, and legs, have great uniformity in structure and number.

The upper arm and thigh-bones.

The forearm and leg-bones.

The hand and foot-bones.

The scapula serves for the attachment of the upper arm, and the innominate bone for the thigh.

The Upper Arm (Humerus) and Thigh-bones (Femur.)

Arm and thigh bones.

These are the largest and strongest long bones of the body. They have at their upper ends hemispherical

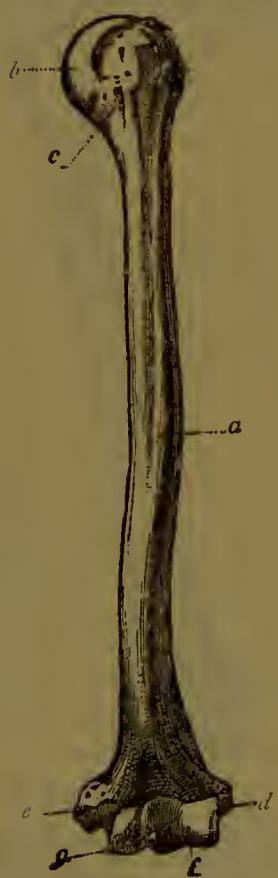


Fig. 16. Left Humerus (front view).

a. Shaft. *b*. Head. *c*. Neck. *d*. Outer condyle. *e*. Inner condyle. *f*. Articular surface for the radius. *g*. Articular surface for the ulna.

Fig. 17. Forearm. Left.

a. Ulna. *b*. Semilunar articular surface for the humerus. *c*. Olecranon process. *d*. Head of the ulna. *e*. Styloid process. *f*. Radius. *g*. Neck of radius. *h*. Head of radius. *h*. Tuberosity of the biceps. *i*. Lower end of radius with articular surface for the first row of hand-bones. *k*. Styloid process.

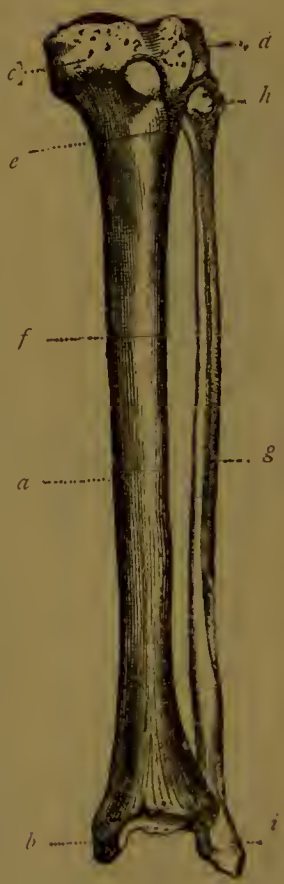


Fig. 18. Leg.

a. Shaft of tibia. *b*. Internal malleolus. *c*. Inner. *d*. Outer condyle. *e*. Tubercle of the tibia. *f*. Crest of the tibia. *g*. Fibula. *h*. Head of fibula. *i*. Outer malleolus.

surfaces, which articulate with the glenoid cavities of the scapulæ and innominate bones. At their lower ends, which are wider, and flatter than the upper ones, are two lateral protuberances (condyles) and also articular surfaces for the forearm and leg. The shaft of each bone is round, and, especially in the thigh, somewhat curved.

The humerus and femur have an unusually free range of movement, owing to the spherical shape of their joint surfaces.

Between the head or upper articular surface of the femur and the shaft lies the neck of the bone, set at an obtuse angle.*

Forearm and leg bones.

The forearm and leg each consist of two long tubular bones; those of the former are the ulna and radius, of the latter are the tibia and fibula.

The bones of the forearm are movable on each other in their long axis, hence the free mobility of the hand in this direction. The bones of the leg are strongly united by ligaments.

The bones of the upper arm and forearm form at their junction the elbow-joint.†

Between the femur and the tibia formed by these two bones is the knee-joint. On the anterior surface of this joint is the patella or knee-cap, a flat, movable, triangular bone, united by tendon with the muscles of the thigh, and attached to the tibia below by a strong ligament.‡

Bones of the hand.

The hand consists of twenty-nine separate bones, which are beautifully joined together by small articular surfaces and strong ligaments, and give unusually free movement to it. There are about forty muscles attached to it which bring about the separate movements.

The eight small bones of the hand (carpal bones) are closely attached to the forearm; they are arranged in two rows, and are united together by short strong ligaments.

* Old people frequently break this part of the femur when they fall. Repair of such a fracture takes place very rarely, because the neck of the femur does not contain many blood-vessels, which are necessary for the formation of callus (see p. 2).

† Over-extension of the forearm is prevented by a process of bone which extends backwards from the ulna, and when the arm is fully extended, fits into a depression on the posterior surface of the upper arm.

Close to this bony prominence, lying in a furrow at its inner side, is the large ulnar nerve. If this is pressed upon or bruised, severe pain is at once felt, extending to the tips of the fourth and fifth fingers, in which this nerve ends.

‡ The kneecap protects the joint from blows and pressure. Between the joint surfaces of the knee are discs of cartilage, which diminish the effect of certain blows which reach the body in a longitudinal direction, as in a fall on the feet; they are like the intervertebral discs of the spine.

The five middle bones of the hand (metacarpal) are joined to these carpal bones; they are small, and cylindrical in shape, and do not possess much movement. Only the thumb has a spherical joint surface; it has, therefore, a greater range of movement than the fingers. Three shorter bones go to each finger (the thumb has only two); they form the knuckles, and can be moved on each other * in opening and closing the hand.

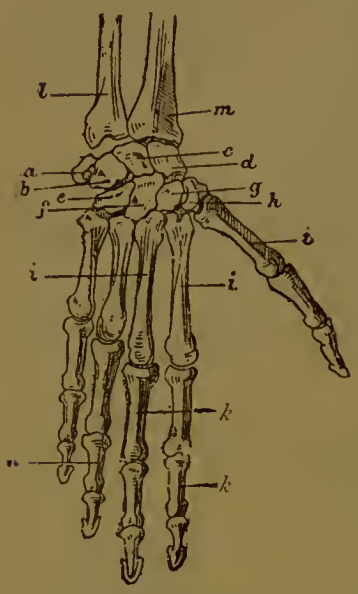


Fig. 19. The Hand.
a. Pisiform. *b*. Cuneiform. *c*. Semilunar. *d*. Scaphoid. *e*. Unciform. *f*. Os magnum. *g*. Trapezoid. *h*. Trapezium. *ii*. Metacarpal bones. *k*. Finger bones. *l*. Ulna. *m*. Radius.

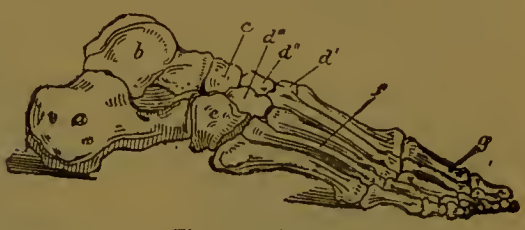


Fig. 20. The Foot.
a. Os calcis. *b*. Astragalus. *c*. Scaphoid. *d'*. 1st Cuneiform. *d''*. 2nd Cuneiform. *d'''*. 3rd Cuneiform. *e*. Cuboid. *f*. Metatarsal. *g*. Toes.

Bones of the foot.

The foot (Fig. 20) is formed like the hand. It consists of seven small bones (I. 29) (tarsal bones), five middle or metatarsal bones (I. 30†), and sixteen phalanges. Their range of movement is considerably less than those of the hand.

III. The Teeth.

Kinds of teeth.

Man has in middle life thirty-two teeth, which are placed evenly opposite each other in the upper and lower jaws.

There are 8 incisor teeth,
4 eye or canine teeth,
20 molar teeth.‡

* On the inner surface of the thumb, between the first and middle joints, are two sesamoid bones, as large as a pea, which serve as pulleys for certain tendons.

† If the necessary movement is absent in the metatarsal bones so that they lie flat, and the whole of the sole touches the ground, a condition of flat foot arises, which is a hindrance in walking, and soon causes weariness. By wearing too narrow boots the toes and the whole foot become pained and crippled.

‡ In certain kinds of mammals, according to their manner of life and feeding, one or another kind of tooth is considerably developed; for instance, the incisor teeth in rodents, for gnawing hard objects: the canine teeth in beasts of prey, for seizing their prey; the molar teeth in hoofed animals for chewing and masticating parts of plants.

Parts of the tooth.

Each tooth consists mainly of dentine, a kind of bone, which forms the ground substance, and contains one or more cavities and canals in which the nerves and blood-vessels lie.

The exposed part of the tooth is covered with enamel, a very hard, rigid, white, or yellow-white substance, which frequently cracks when hot food or drink acts on it, or hard objects (such as metallic toothpicks and nails) are forced between the teeth, or nuts, &c., are cracked. The loosened or cracked pieces of enamel, or dentine, never become attached again.*

The parts of a tooth are—

The crown, the exposed visible part covered with enamel (Fig. 21).

The root, the part buried in the jaw and covered by the gums.

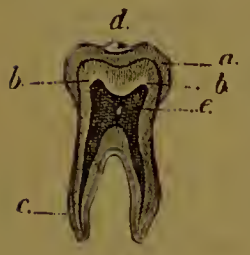


Fig. 21. Molar tooth, with two roots or fangs. *a*. Enamel. *b*. dentine. *c*. root or fang. *d*. crown. *e*. neck. *f*. pulp cavity.

The crown is shaped like a chisel in the incisor or front teeth, pointed in the canine or eye teeth, uneven and broad in the molar or back teeth. According to these different shapes of the crown the teeth serve for cutting, holding fast, and chewing or grinding food. That part of the tooth which lies between the crown and root is called the neck.

The roots of the teeth are peg-shaped and firmly fixed in the jaw. The incisor, canine, and anterior molar teeth have one root only, the remaining molar teeth from two to four roots. At the point of the root the nerves and vessels enter the tooth from beneath.

When the teeth are sound they do not ache, but when the nerves and soft parts of the inside of the teeth are inflamed and swollen they are painful. If the interior soft parts are exposed by the teeth becoming hollow, changes of temperature of the air, the mastication of food, etc., give rise to the most acute pain.

The teeth at different ages.

From the 7th to the 9th month of infancy the incisor teeth first appear; at the end of the second year, about twenty teeth can be counted—the milk teeth. These teeth have either no roots or very insignificant ones. These teeth fall out

* In this way the dentine is exposed, and, as this is much softer than the enamel, corroding fluids and decomposing foods very soon destroy it, the tooth becomes hollow and finally breaks off. The germs of fungi grow in hollow teeth.

Tartar, a strong yellow substance which is deposited at the lower part of the crown (the neck of the tooth), and presses back the gum, consists of a calcareous substance, which is gradually formed from the food. In order to protect the teeth from this danger, the greatest care must be taken to clean them daily with tooth-powder or cleansing fluid. Hollow teeth should be properly stopped, that is, filled with metal, in order to prevent the advance of the decay; broken teeth must be replaced by artificial ones. Unsound and defective teeth cannot properly mince the food, digestion is thereby impaired, and the body improperly nourished.

from about the seventh year onwards, to be replaced by fresh permanent ones.

From about twenty to twenty-five years of age the last four back teeth appear—the wisdom teeth. The number, thirty-two, is then complete.*

SECOND PART.

THE SOFT PARTS COVERING THE SKELETON.

I.—The Muscular System (Plate II).

MUSCLES. LAYER OF FAT. SKIN.

THE muscles are called in ordinary life the flesh or meat. By means of their peculiarity of being able to shorten themselves—the power of contractility—they bring about all the movements which we observe in the body.†

The cause or stimulus of this contractility originates in the nerves, which, arising from the brain and spinal cord, branch out into the individual muscles and groups of muscles.‡

Constitution and distribution of the muscles.

The muscle substance consists of innumerable fine red fibres, invisible to the unaided eye, and united together in bundles. Under the microscope these fibres appear sometimes smooth, sometimes transversely striped. §

* It seldom happens that teeth appear in later life. For the most part they fall out in time. the cheeks sink in in consequence, the chin advances, and the mouth falls in. The eruption of teeth is generally accompanied by pain, and often causes in children congestion of the brain, and consequent convulsions.

† For instance, the movements of the limbs, heart, intestines, &c., are entirely caused by muscular action. When we walk or stand, laugh, weep, sing, move the eyes or tongue, or wrinkle the brow, a number of muscles act by reason of our conscious power over their contractility.

‡ If this connection is broken, that is, if the nerve is destroyed at its origin in the brain, or in its course to the muscle by injury or disease, for example, by hæmorrhage in the brain (apoplexy), the muscle is paralysed. If the nerve is irritated. the muscle falls into a condition of unhealthy contraction. In convulsions the muscles are involuntarily contracted by an unhealthy stimulus proceeding from the brain or spinal cord. It is the same in epilepsy, lockjaw, &c

§ Muscle substance is compounded of about 18 kinds of material, 2 parts of albumen, 3 parts of salts, and 77 parts of water. From the amount of water in it arises the moistness of fresh meat (meat juice). If meat is boiled for a long time, only dry fibres remain at last, which contain very little nutriment.

The Muscles of the Human Body.

A. Frontal bone.
B. Temporal bone.
C. Malar bone.
D. Inferior maxillary bone.
E. Clavicle, or collar-bone.
F. Sternum, or breastbone.
G. Thyroid cartilage.
H. Olecranon process.
I. Posterior annular ligament.
K. Anterior annular ligament.
L. Ligaments.
M. Ligaments.
N. Crest of the ilium.
O. Knee-cap (patella).
P. Lower end of the femur.
Q. Tibia.
R. Interarticular fibro-cartilage of knee-joint.
S. Ligamentum patellæ.
T. Head of the fibula.
U. Tibia, or shin-bone.
V. Fibula.
W. Annular ligament.
X. Ligament.
Y. Tarsal and metatarsal bones.
Z. Tendon of Achilles.
*Z**. Ligaments.

Head Muscles.

1. } Occipito-frontalis muscle.
3. }
2. Temporal muscle.
4. Orbicularis palpebrarum muscle.
5. Attrahens aurem muscle.
6. Zygomaticus major muscle.
7. Zygomaticus minor muscle.
8. Levator labii superioris proprius muscle.
9. Levator labii superioris alæque nasi muscle.
10. Compressor narium muscle.
11. Levator anguli oris muscle.
12. Orbicularis oris muscle.
13. Buccinator, or trumpeter's muscle.
14. Depressor anguli oris muscle.
15. Depressor labii inferioris.
16. Masseter muscle.

Neck Muscles.

17. Sterno-cleido-mastoid muscle.
18. Sterno-hyoid muscle.
19. Sterno-thyroid muscle.
20. Thyro-hyoid muscle.
21. Omo-hyoid muscle.
22. Inferior constrictor muscle.
23. Scalenus anticus muscle.
24. Scalenus medius muscle.
25. Levator anguli scapulæ muscle.
26. Splenius colli et capitis muscle.
27. Trapezius muscle.

Body Muscles.

28. Pectoralis major muscle.
29. Pectoralis minor muscle.
30. External oblique muscle.
31. Rectus abdominis muscle.
32. Anterior layer of rectus abdominis muscle.
33. Serratus magnus muscle.
34. Latissimus dorsi muscle.

Arm Muscles.

35. Deltoid muscle.
36. Biceps muscle.
37. Coraco-brachialis muscle.
38. Brachialis anticus muscle.
39. Outer head of triceps muscle.
39°. Middle head of triceps muscle.
39°°. Inner head of triceps muscle.
40. Pronator radii teres muscle.
41. Flexor carpi radialis muscle.
42. Palmaris longus muscle.
43. Flexor sublimis digitorum muscle.
44. Flexor carpi ulnaris muscle.
45. Flexor longus pollicis muscle.
46. Supinator longus muscle.
47. Extensor carpi radialis longior muscle.
48. Extensor carpi radialis brevior muscle.
49. Extensor communis digitorum muscle.
50. Extensor minimi digiti muscle.
51. Extensor carpi ulnaris muscle.
52. Extensor ossis metacarpi pollicis muscle.
53. Extensor primi internodii pollicis muscle.
54. Extensor secundi internodii pollicis muscle.
55. Extensor indicis muscle.
56. External or palmar interosseous muscles.
57. Flexor profundus digitorum muscle.
58. Lumbricales muscles.
59. Abductor pollicis muscle.
60. Flexor brevis pollicis muscle.
61. Adductor pollicis muscle.
62. Abductor minimi digiti muscle.
63. Flexor brevis minimi digiti muscle.

Leg Muscles.

64. Gluteus maximus muscle.
65. Gluteus medius muscle.
66. Tensor fasciæ femoris muscle.
67. Sartorius muscle.
68. Rectus femoris muscle.
69. Psoas and iliacus muscles.
70. Pectineus muscle.
71. Adductor longus muscle.
72. Gracilis muscle.
73. Adductor magnus muscle.
74. Semimembranosus muscle.
75. Semitendinosus muscle.
76. Vastus internus muscle.
77. Vastus externus muscle.
78. Biceps muscle.
79. Tibialis anticus muscle.
80. Extensor longus digitorum muscle.
81. Peroneus tertius muscle.
82. Extensor proprius pollicis muscle.
83. Peroneus longus muscle.
84. Peroneus brevis muscle.
85. Gastrocnemius muscle.
85*. Soleus muscle.
86. Plantaris muscle.
87. Flexor longus digitorum muscle.
88. Tibialis posticus muscle.
89. Flexor longus pollicis muscle.
90. Abductor pollicis muscle.
91. Abductor minimi digiti muscle.
92. Extensor brevis digitorum muscle.
93. Extensor brevis pollicis muscle.

Involuntary muscular fibres.

The muscles with smooth fibres are especially found in those organs which are not under the control of our will, that is to say, whose movements go on without our being able to exercise voluntary control over them, as, for example, in the walls of the stomach, intestine, gall bladder, etc. The nerves of these muscles do not arise from the brain or spinal cord, but in the nerve cells or ganglia.

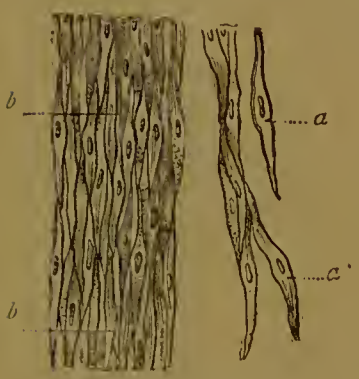


Fig. 22. Involuntary Muscle (× 300).
a. Separate fibres, cells with rod-shaped nuclei. *b*. Layer of muscular fibres.

The smooth, or unstriped muscles, appear in thin membranous layers, they are paler than striped muscle, and consist of short, smooth, spindle-shaped threads, containing a rod-like nucleus. (Fig. 22.)

They have no tendons, they contract slowly, and for the most part by their contraction cause a narrowing of the tubes and canals (stomach, intestines, &c.) which they enclose, whereby an onward movement is given to their contents—the food pulp, and chyle. They lie either in separate bundles or beside and across each other in layers.

Voluntary muscle fibres.

The striped muscles are much more widely distributed. There are about 300 in the human body. The muscles themselves are almost insensitive to injury; they possess, however, what is called a muscular sense, by which we can estimate the weight of a body, and the resistance which it offers.

Fig. 23. Transition from Striped muscle to tendon.

With the exception of the striped muscle of the heart they can be moved at our will; * they determine, as they cover the skeleton, the outward form and roundness of the body, and complete the protecting cavities for the internal organs already formed by the bones (chest and abdominal cavity). As a rule, the striped muscles form long, red, fleshy bundles, which are made up of innumerable separate muscular fibres (Fig. 23.) The larger muscles are thicker in the middle—the belly of the muscle—than at their two ends, where they are joined to tendons. Between the muscles, as much as possible embedded in fat and protected by connective tissue, lie the great nerve trunks and blood vessels.†

* In consequence of this they are also called voluntary muscles, while the unstriped muscles, over which the will has no power, are called involuntary muscles.

† If a muscle is overstrained it becomes weakened, and paralysis not infrequently

By contraction of the muscles the blood-stream in the vessels is aided. By means of these tendons, which can be observed as thin continuations of the muscles, and appear as very strong white shining bands or round cords, the muscles are joined to the bones, especially in the neighbourhood of the joints. Certain muscles have two or more tendons of origin. The tendons of the hand and fingers are very beautifully attached and united together in order to produce the most complex movements.

By contraction of the muscles the points of attachment on the bones are brought nearer to each other, and a corresponding movement of approximation of the limbs or parts of the body concerned results. The form of the muscles varies.

Elongated muscles are especially found round the long bones and grouped together in the back.

Flat muscles, which have short tendons and which are especially flattened out in one direction, mostly cover the flat bones, and exist in much smaller numbers. The largest flat muscle is the diaphragm; this separates the cavity of the chest from that of the abdomen. Those muscles which close the various openings of the body (like the mouth, eye, &c.) are called sphincters. Flexor muscles are those which bend the bones on one another, the extensors are those which straighten them. Finally, adductor and abductor muscles move the limbs to or from the middle line of the body.

According to their position they are called chest, arm, trunk muscles, &c.

The heart consists almost entirely of muscle. Its movements, which are independent of our will, go on quickly and forcibly. The muscle fibres of the heart, as microscopic examination shows, possess in part the characters of striped or voluntary muscle, in part those of involuntary

follows. After every exertion a certain amount of rest is necessary. Long-continued want of use makes the muscle flabby, and leads to its wasting and fatty degeneration. Long standing or sitting is very fatiguing, because the same group of muscles is kept on the stretch. Children cannot sit long without bending their backs. In walking, the muscles are exercised in turn and rest in turn.

After death the substance of the muscle fibre coagulates, the muscles become solid and rigid. This is called the onset of rigor mortis. It begins in the first twelve hours after death, and lasts about forty hours. After this time putrefaction begins.

By regular and methodical practice the muscles can be extraordinarily strengthened, especially by gymnastics, swimming, drill, &c.

We learn to use our muscles properly only by degrees. The child makes the most awkward and purposeless movements. In a quiet and inactive existence the muscles lose power and size—they atrophy.

When a muscle contracts it becomes shorter and harder, as can be felt on the front of the upper arm when the forearm is bent up. Wasted or atrophied muscles can, if the nerve is healthy, be strengthened by practice.

muscle. Their quick movement is characteristic of voluntary muscle, and the absence of control of the will is characteristic of involuntary muscle.

The most important superficially situated muscles of the human body : *—

(A.) The Head. (II. 1 to 16.)

NAME.	SITUATION.	ACTION.
Frontalis muscle. (II. 1.)	A broad, flat muscle on each side of the forehead.	Draws the scalp forwards and wrinkles the brow.
Occipitalis muscle. (II. 3.)	Opposite the last on each side of the occipital bone.	Draws the scalp backwards.
Temporal muscle. (II. 2.)	Covers the temporal bone. Attached to the upper part of the lower jaw.	Moves the lower jaw upwards and backwards.
Orbicularis muscle of the eye. (II. 4.)	In a circle surrounding the orbit.	Closes the eye.
Zygomatic muscles, greater and smaller. (II. 6 & 7.)	Arise from the malar bone. Run to the upper lip.	Draw the upper lip upwards.
Masseter.† (II. 16.)	Very thick and strong. Runs from the malar bone to the lower jaw.	A powerful muscle of mastication. It draws the lower jaw with great force up to the upper jaw.
Buccinator. (II. 13.)	Forms the muscular or fleshy part of the cheek.	Narrows the mouth cavity, presses the air out of it, and draws the angle of the mouth outwards.
Levator of the angle of the mouth and lower lip. (II. 14 & 15.)	Between the lower lip, chin, and angle of the jaw.	Draws the angle of the mouth and lower lip downwards.
Orbicularis or sphincter of the mouth.	In a circle round the mouth.	Closes the mouth.

* As already mentioned, the number of muscles which perform the complicated movements of the body is very considerable. It would lead us too far if we were to mention all the muscles of the body here. Some of them are so small that they only consist of a few bundles of fibres. Almost all the muscles mentioned here are present in pairs, symmetrically placed on each side of the body.

† The masseter in many animals, especially in the flesh eaters, is unusually strong and large.

(B.) Neck and Trunk. (II. 17 to 34.)

NAME.	SITUATION.	ACTION.
Sterno-cleido-mastoid. (II. 17.)	At the side of the neck.	Bends the head downwards.* If the head is fixed, both muscles raise the clavicles together with the chest, they are, therefore, powerful muscles of respiration.
Trapezius. (II. 27.)	On the neck and posterior surface of the chest on both sides of the spine, shaped like a monk's hood; is attached to the upper arm.	Draws the upper arm backwards.
Pectoralis major. (II. 28.)	On both sides of the chest.	Draws the upper arm towards the chest.
Serratus magnus. (II. 33.)	Arises by many heads of origin from the upper ribs. surrounds the lower lateral part of the chest, and is attached to the shoulder blade.	Draws the shoulder blade forwards and the ribs outwards and upwards.
Latissimus Dorsi. (II. 34.)	Covers the greater part of the back, loins, and sacrum, and is attached to the upper part of the upper arm.	Draws the arm backwards.
Obliquus abdominis and Rectus abdominis. (II. 30 & 31.†)	The former forms the side wall of the abdomen, the latter which runs from above downwards in the middle line forms its anterior wall.	They press on the abdominal organs and narrow the abdominal cavity.

* If only one muscle is acting the head will be drawn sideways and downwards but if both act, they bend the head straight forwards and downwards.

† The muscles (II. 18 to 22.) omo-hyoid, scaleni, sterno-hyoid, sterno-thyro and stylo-hyoid, are small bundles of muscular fibre which serve to move the hyoid bone, larynx, and upper ribs.

(c.) The Limbs. (II. 35 to 93.)

1. The arm and the hand (upper extremity).

NAME.	SITUATION.	ACTION.
Deltoid. (II. 35.)	A strong, fleshy, triangular muscle which covers the upper part of the shoulder and shoulder joint.	Raises the upper arm.
Triceps. (II. 39.)	Originates by three heads from the shoulder blade and humerus, covers the whole posterior surface of the upper arm, and is attached to the posterior part of the ulna.	Extends the forearm.
Biceps. (II. 36.)	Arises by two heads from the shoulder blade, covers (with the next muscle) the anterior surface of the upper arm, and is attached to the radius just below the elbow.	Flexes the forearm
Brachialis Anticus. (II. 38.)	Lies under the biceps.	Acts with the biceps.
Supinator longus. (II. 46.)	Lies on the outer side of the radius.	Draws the radius with the hand attached to it outwards.
Extensors of the hand and fingers. (II. 47 to 51, and 53 to 55.)	Arise from the outer condyle of the humerus, placed at the outer side of the radius.	Extend the fingers together or separately, and turn the hand to the right or left.
Flexors of the hand and fingers. (II. 41, and 43 to 45.)	Arise from the inner condyle of the humerus, and cover the elbow joint.	Flex the fingers on the palm and the hand towards the radius or elbow.
Interosseous muscles. (II. 58.*)	The outer ones lie at the back of the hand, the inner ones in the palm between the metacarpal bones.	Move the metacarpal bones towards or away from each other.

* The ball of the thumb consists of four short, thick muscles, that of the little finger of three similar ones.

2. Leg and foot (lower extremities).

NAME.	SITUATION.	ACTION.
Gluteus maximus. (II. 64.)	Covers the posterior part of the sacrum and innominate bones of the pelvis.	The most powerful muscle of the human body, it extends the hip joint backwards and outwards. Beneath it lie the gluteus medius and minimus.
Rectus, and Quadriceps extensor cruris. (II. 68, 76, 77.)	Arising from the innominate bone or upper part of the femur, they cover the anterior and lateral parts of the femur, and are attached to the patella.	They extend the leg.
Sartorius. (II. 67)	The longest muscle of the body, lies on the anterior surface of the thigh, passes obliquely from above downwards and inwards to the tibia.	Helps to flex the leg, draws it towards the thigh.
Gracilis. (II. 72)	At the inner side of the thigh.	Acts with the last muscle.
Semi-membranosus and biceps. (II. 74 and 78.)	At the outer posterior part of the thigh.	Flex the leg.
Adductors of the thigh. (II. 71, 73.)	At the inner side of the thigh.	Draw the thigh inwards
Gastro-cnemius and soleus. (II. 85)	Form the calf of the leg.	Extend the foot.
Peroneus longus and long extensor of the toes. (II. 83 and 80.)	Both lie on the outer side of the leg.	The former extends the foot outwards, the latter the toes.
Tibialis anticus and Peroneus tertius. (II. 79 and 81.)	At the outer side of the shin bone.	Flex the foot inwards and outwards.
Tibialis posticus. (II. 88.*)	At the posterior surface of the tibia.	Extends the foot towards the inner side.

* There are also a number of other muscles present, which serve as flexors, extensors, and abductors of the toes (II. 86, 87, 89 to 93).

Many muscles, given in the Tables, have, on account of brevity, no mention here. In the muscles of man, as well as of many animals (pig, fox, rat, mouse, &c.), there are frequently found trichinæ, which are small worms rolled up into a coil about

II.—The Layer of Fat.

In every well-nourished man there is, under the skin, between it and the muscles, a more or less thick layer of fat.

Structure of the fat layer.

This is formed of small, microscopic cells, each of which contains a drop of fat.

These cells are imbedded in connective tissue, a network of fine fibrous threads, which unites the skin to the superficial muscles.

Fat is distinguished chemically from muscle substance and the other parts of the body in that it contains no nitrogen.

Use of the fat.

The fat serves as a cushion and protection for the underlying parts, it gives the limbs their roundness and beautiful form, and, as a bad conductor of heat, protects the body against cold; it does not allow the warmth of the body to escape easily, nor the surrounding cold to penetrate easily. When necessary nourishment from without, by food and drink, cannot be conveyed to

1 mm. long. These lie inside the muscular bundle in a more or less calcified capsule; they develop very quickly when they reach the stomach or bowel of man and certain animals. This happens, for example, when a man eats raw or insufficiently cooked trichinous pork; the capsules surrounding the trichinæ are dissolved by the gastric juice. When set free in this way, they grow very quickly, pass into the small intestine, and develop into male and female trichinæ. The former have a length of only 1·5 mm., the latter of 2 to 2·5 mm. In a short time young ones are developed inside the female; these escape, penetrate the wall of the intestine, and pass directly, or by means of the blood current into all, even the most remote voluntary muscles. Here they establish themselves, obtain their nutriment from the muscle substance, and when they have reached a size of about 1 mm., come to rest, roll up, and become encapsuled. Gradually the soft capsule becomes calcareous, but within it the trichina remains alive for many years.

During their wandering to the muscles, and their subsequent growth, each trichina causes slight inflammatory irritation. The worms are often present in the human stomach and intestine in very great numbers; further, each female trichina contains a large number of young, so that it is not surprising that these wandering trichinæ, sometimes amounting to millions, lead to severe symptoms of disease in the muscles, very great pain, and often to death. When the trichinæ once become encapsuled they give rise to no more trouble.

Whence the pig obtains the trichinæ is not yet known with certainty; either from the rat which it eats, or from the refuse of slaughtered trichinous pigs which it sometimes devours.

With a little practice it is not difficult to recognise the trichinæ with a simple microscope. (See Fig. 48, p. 78.)

It is only possible to avoid trichinosis by not eating raw or insufficiently cooked pork. A heat of at least 180° Fah. is necessary to kill the trichinæ. Smoking and salting the meat, if it is not very thoroughly done, does not kill them.

Cysticercus cellulosæ, an intestinal worm, the larval condition of the tapeworm, occur in human muscle as white bladders as large as a pea, filled with fluid.

the body, as, for example, in severe diseases,* the fat is dissolved, it is taken up by the blood, and serves as nourishment to the body.

III.—The Skin.

Hair and Nails. Fig. 24.

The outer skin, which forms a strong protecting covering to the body 2 to 6 mm. thick, is the seat of the sense of touch, and serves for the excretion and absorption of certain materials; it consists from within outwards of three layers:—

The cuticle,
The mucous layer,
The corium.

Fig. 24. Vertical Section of Skin. (× 15 to 20.)

a. Epidermis or cuticle. *b*. Mucous layer. *c*. Pigment layer. *d*. Dermis or corium. *e*. Papillæ. *f*. Sweat gland with duct *g*. *h*. Sebaceous gland with duct *i*. *k*. Hair follicle. *l*. Hair papilla or germ. *m*. Hair bulb. *n*. Hair root. *o*. Hair.

Beneath the latter lies the layer of fat, which, as above described, unites the skin with the muscles.

The cuticle. The cuticle consists of dry, transparent, horny, flat, microscopic cells in thick layers one over the other, the surface ones are very easily removed by washing, rubbing, etc.

It is devoid of vessels and nerves, as thin as paper, and shows on its outer surface fine openings or pores arranged in rows, the openings of the sweat and sebaceous glands.†

The mucous layer. The mucous layer lies under the cuticle between this and the corium. It forms a thin layer and consists of very small fine white cells which in negroes, as in all coloured

* While long and especially febrile diseases lead to a diminution of fat, where there is great ease of mind and body, and at the same time plentiful use of nourishing food and drink, especially of spirits (brandy, &c.), an unnatural deposit of fat (corpulence or obesity) takes place; this may lead to several conditions dangerous to life (fatty degeneration of the internal organs). Fat men are, therefore, not strong.

By artificial feeding of certain domestic animals (pig, goose, etc.) an unnatural fatty deposit can be produced in the internal organs.

† If continuous or often repeated pressure is exerted on certain parts of the surface of the body, the cuticle becomes thickened, as can be seen in the hands of working men. By the pressure of narrow shoes small, horny thickenings arise on the toes or other parts of the foot known as corns. By pressure on the underlying periosteum, etc., considerable pain and inflammation may arise. By overgrowth in certain places of the corium and cuticular layers warts are produced.

races contain the colouring matter which gives the skin its tint.* This first appears a few days after birth.†

As the outermost cells of this layer gradually dry, the cells of the cuticle continually cast off from the surface are replaced from below.‡

The Corium.

The corium is of different thickness in different parts of the body; it is very rich in blood-vessels and nerves.§ It forms on its outer surface directed towards the mucous layer numerous small elevations—the touch papillæ. ‖ The nerves of touch end in these. They are to be regarded, therefore, as true sense organs. The touch papillæ and the depressions between them are everywhere covered by the mucous layer. In the deeper layers of the corium lie the sebaceous and sweat glands whose ducts discharge on the surface.

Sebaceous glands.

The sebaceous glands secrete a fatty, sebaceous substance which keeps the skin sort and supple. They lie more superficially than the sweat glands.** Many sebaceous glands discharge into the hair follicles, others on the surface.

Sweat glands.

The sweat glands secrete the sweat. They form tubes which are coiled up into a globular mass in the under layers of the corium or fatty layer. From them a corkscrew-shaped duct

* Sometimes also in white races local patches of pigmentation of the skin are found, which are known as moles, liver spots, and freckles. In nævi generally a considerable development of fine bloodvessels is found.

† Negroes are born with the same coloured skins as Europeans; the pigmentation of the skin begins at the fifth or sixth day after birth.

‡ When unusually severe irritation (as with boiling water, Spanish fly blisters, or contusions) acts on the skin, fluid is poured out in the mucous layer, and the cuticle is separated in the form of blisters (water blisters). If the fluid is mixed with blood, which comes from injured blood-vessels, blood blisters are formed.

§ The corium is thickest, 6 mm., on certain hard parts of the body—head, back of neck, back, and heels; thinnest on the face, front of the neck, &c. By blows, injuries, or contusions of the skin, pain is caused. This is caused mainly by the rupture of blood-vessels, blood is poured out under the skin, a bruise is produced which is at first of a blue colour. This assumes later a green and yellow hue owing to changes in the blood.

‖ The touch papillæ are especially numerous in the finger tips, under the nails, and in the soles of the feet. Their presence in greater or less numbers in different parts of the body determines a greater or less development of the sense of touch.

** If the sebaceous glands become blocked, the sebaceous substance accumulates, and the little swellings produce spots known as acne. Round the sebaceous glands there are little bands of involuntary muscle; when these contract they produce "gooseskin." The sebaceous glands are very plentiful on the nose, forehead, &c. They are absent in the soles of the feet and palms of the hands. The sebaceous glands and their neighbouring parts often inflame, and little pustules are formed.

Scabies or itch is a disease of the skin in which pustules and scabs form on the skin. This irritating eruption is entirely caused by small, scarcely visible insects which bury themselves in the skin, quickly increase, and can be communicated from one person to another.

about $\frac{1}{30}$ mm. thick carries the excreted fluid, the sweat, outwards on to the surface of the skin.

The number of sweat glands varies in different parts of the body: they are especially plentiful on the palm of the hand and sole of the foot, but are scarce in the back. Their number amounts to many millions.

The sweat consists mainly of water and salts.*

The Hair.

The hairs are fine, elastic threads of varying length and colour, and scattered almost over the whole body. They are divided into the shaft,† the part above the surface of the skin, and the root, which swells at its lowest part to form the bulb. The two last portions lie in a canal which penetrates to the corium, into which the ducts of the sebaceous glands empty themselves.‡ The soles of the feet, and the palms of the hands are quite free from hairs. The depression in the skin, an elongated tube in which the hair lies is called the hair sac or follicle.

Colour. The outer layers of the shaft of the hair consist of firmly united, horny, transparent plates or cells. These form the cuticle of the hair. Beneath this is a layer of succulent coloured cells which in part give the hair its peculiar colour. When these dry up they die, the colouring matter disappears, and the hair turns grey or white. In the interior of the hair is the medulla consisting of succulent coloured cells (according to the colour of the hair).

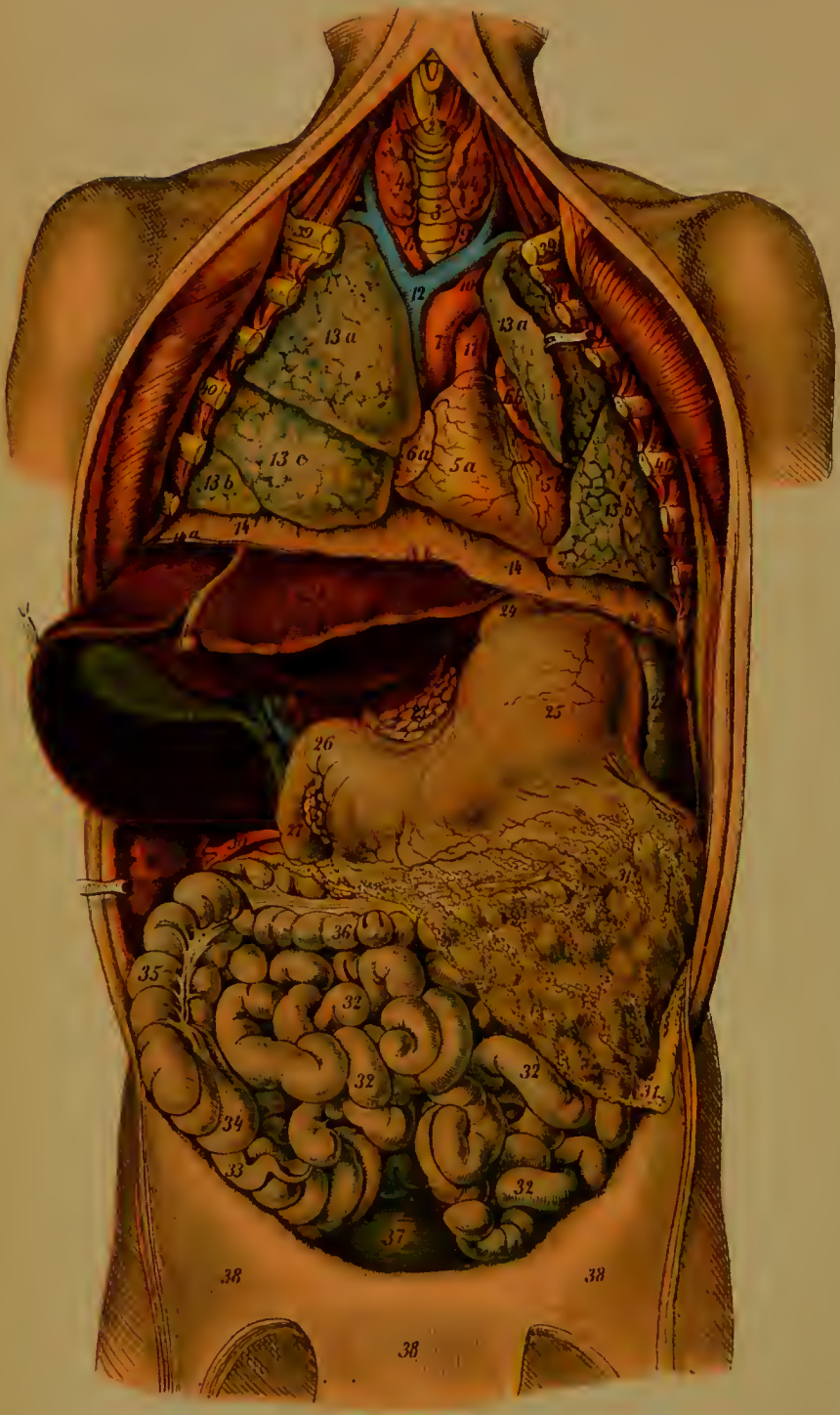
Nutrition. The nutrition of the hair is derived from the lowest part of the bulb, where there is a small elevation consisting of vessels and nerves—the hair germ or papilla. This supplies nourishment to the cells contained within the shaft of the hair.

* By sweat the body is cooled, deprived of excessive moisture, and the blood purified of certain ingredients. Fluid and gaseous substances penetrate from without scarcely at all, or with very great difficulty. If perspiration is suppressed, useless materials remain in the blood. Widespread burns of the skin are, therefore, very dangerous, because perspiration through the skin is more or less prevented.

† Straight and smooth hairs have a round shaft, but curly hairs are flattened. If the hair is not cut it only grows to a certain length. Hair turns grey in consequence of the entrance of air into and disappearance of colour from the shaft. If the hair papillæ are attached to the hairs which have fallen out, the hair is not replaced, and grows no more. If the hair only breaks off, by appropriate applications the normal growth can be reproduced. Tying the hair too tightly destroys it, also dyeing. Hot covering for the head should also be avoided.

‡ These sebaceous glands frequently fail to secrete the necessary oily matter; in these cases it is advisable to apply fatty matter to the hair artificially by oil or pomade.

The Internal Organs of the Chest and Abdomen.



1. Thyroid cartilage.
2. Cricoid cartilage.
3. Trachea.
4. Thyroid gland.
5*a*. Right ventricle of heart.
5*b*. Left ventricle of heart.
6*a*. Right auricle of heart.
6*b*. Left auricle of heart.
7. Aorta.
8. Innominate artery.
9. Left carotid artery.
10. Left subclavian artery.
11. Pulmonary artery.
12. Vena cava superior.
13*a*. Superior lobes of lung.
13*b*. Inferior lobes of lung.
13*c*. Middle lobe of right lung.
14. Diaphragm.
14*a*. Muscular portion of diaphragm.
14*b*. Central tendon of diaphragm.
15*a*. Right lobes of the liver.
15*b*. Left lobes of the liver.
16. Suspensory ligament of the liver.
17. Gall-bladder.
18. Cystic duct.
19. Hepatic duct.
20. Common bile-duct.
21. Portal veins.
22. Hepatic artery.
23. Pancreas.
24. Lower part of œsophagus or gullet.
25. Stomach.
26. Pylorus.
27. Duodenum.
28. Spleen.
29. Right kidney.
30. Right renal artery.
31. Great omentum.
32. Small intestine.
33. Appendix vermiformis.
34. Cæcum.
35. Ascending colon.
36. Transverse colon.
37. Urinary bladder.
38. Peritoneum.
39. Clavicles, or collar-bones.
40. Ribs.

The short, fine hairs are called downy hairs. Hairs easily take up water, and as easily part with it. They are very hygroscopic. In this way they change their length and appear sometimes soft, sometimes harsh and dry.

The Nails.

The nails are thin, horny plates which lie flattened out on the back of the tips of the fingers and toes.

They consist of a body and root.

Root. The root is the lowest invisible part of the nail buried in a fold of skin very rich in blood-vessels. This is quite soft, and at its posterior growing part forms the bed of the nail; by a constant production of new cells the nail is constantly thrust forwards.

Substance. The body of the nail is attached on one side to the corium, and consists of a very thick layer of horny plates (dried cells), just like the cuticle. The corium beneath the nail is very rich in touch papillæ, and therefore very sensitive.*

THIRD PART.

THE INTERNAL ORGANS OF THE HUMAN BODY.

Organs of Respiration. Vascular System.
Organs of Digestion.

Plate III.

Preliminary Remarks.

Separation of chest from abdomen. In the interior of the body we find two great cavities, the chest and abdomen. They are completely separated from each other by the Diaphragm. This is a large oval flattened muscle, its inner part being tendinous, firmly attached to

* The nails should be treated with care. If they are not cut often enough they become stunted, and grow into the skin, especially in the toes, in consequence of the pressure of tight boots. By biting the nails, the nail itself as well as the whole end of the finger is disfigured. If the nails are not cut at all they grow to a length of 3 to 4 cm. Some nations let them grow intentionally.

Diaphragm. the inner surface of the lower ribs and to the spina column, and forming a horizontal partition. This muscle is of a dome shape, the convexity being upwards towards the chest. In inspiration it flattens down, that is, it contracts; by this means the chest is deepened, and, in order to avoid a vacuum, fresh air streams into the lungs from without through the larynx and trachea. After a short time the contraction of the diaphragm relaxes, and the air, after it has given up certain substances to the blood, is breathed out again.*

Several openings for the passage of blood vessels and the gullet are present in the posterior part of the diaphragm.

Lining membrane. The chest, as well as the abdomen, is lined everywhere with a thin, delicate, blue-white, tendinous, strongly adherent membrane, which is called—

The pleura in the chest,
The peritoneum in the abdomen.

These membranes, which belong to the group of serous membranes, secrete on their free surface a certain amount of moisture or serum,† the object of which is to keep the surfaces of the organs contained in the cavities moist, and to prevent friction against the other organs.

Pleura. The pleura lines the inner surface of the thorax, covers the root of the lung and the lung itself, and is firmly united to the surface of these organs.‡

Peritoneum. Likewise, the organs of the abdomen (stomach, intestines, spleen, kidneys, liver, &c.), are wholly or partly covered with peritoneum.

Omentum. This forms also two large folds or sacs, lying on the stomach, and consisting of several layers, which contain much fat and form a warm protecting covering for the abdominal organs. These flat protecting folds of the abdomen are called the greater and lesser omentum.

Mesentery. The peritoneum almost completely lines the inner surface of the abdominal wall; it also forms a covering to the intestines, and a membranous band which serves to attach the

* In man, when there is danger of suffocation, after being taken to the open air, artificial respiration must be done on the patient. This consists of often repeated methodical compression of the thorax, followed by raising of both arms over the head, as well as by turning the body from back to side. By these movements the chest is alternately expanded and contracted, and artificial respiration is carried out.

† In some diseases this fluid is often poured out in great quantity, and forms an effusion of fluid in the chest or abdomen.

‡ Both pleura and peritoneum are very sensitive, and have a great tendency to inflammation.

latter to the front of the spine; by this means fairly free movement is permitted to the bowel, at the same time that the risk of twisting is avoided. These bands or folds of peritoneum contain large numbers of glands (mesenteric glands) between their layers, and are known as the mesentery.

Mucous membranes.

Other not less important membranes very widely present in the human body are the mucous membranes.

These are thin velvety grey or red membranous layers, rich in blood-vessels and nerves, which are formed of several layers of different shaped cells, just like the outer skin; they form the inner surface of the greater number of canals and cavities* with the exception of the blood-vessels, and secrete a sticky substance, mucus, on their surface.

Just as the outer skin covers the outer surface of the body, so the cavities, which communicate by natural openings (mouth, nose, &c.) with the outer surface, are universally lined by mucous membrane. At the natural openings, like the lips, the mucous membrane passes directly into the skin.

The mucous membranes are covered all over with little depressions scarcely visible to the naked eye called glands; these are to be regarded as mucus-secreting organs. The object of the mucous membranes is to keep the inner surface of the channels or cavities moist and slippery.†

The mucus secreted by the stomach and intestines plays an important part in the digestion of food.

The mucous membrane is bound down to the subjacent organs and walls of the cavities by a loose cellular network formed of very fine fibrous filaments.

I.—The Respiratory Organs.

Larynx, Trachea, Lungs.

Air is carried to the organs of respiration by the nose and mouth, it then passes through the larynx and trachea.

* Mucous membrane is found throughout the whole alimentary canal. Mouth, gullet, stomach, intestines, in all the air tubes, larynx, trachea, lungs, in the ducts of glands, in the gall bladder, &c.

† In disease this fluid is often poured out in unusually great quantity, as happens in inflammation of the mucous membrane. We then speak of catarrhs of the lung, stomach, nose, larynx, eye, &c. The mucous secretion shows an abnormal constitution; it is either very thin or purulent.

In croup an inflammation of the mucous membrane of the larynx takes place; a coagulative fluid is poured out instead of the ordinary mucus of simple catarrh. The croupous membrane thus formed narrows the glottis and air passage, and in children brings about danger of suffocation. A similar process occurs in diphtheria.

The Larynx.

The larynx (Figs. 25 and 26) lies beneath and behind the tongue and hyoid bone, in the middle of the front of the neck in front of the cervical vertebræ; it consists of cartilage, and forms the entrance to the trachea. All the air which is breathed in and out must pass through the larynx.

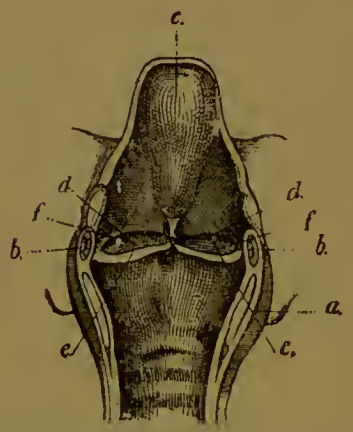


Fig. 25. The Larynx open from behind.
a. Cricoid cartilage. *b*. Arytenoid cartilage *c*. Epiglottis, posterior surface. *d*. The upper or false vocal cords. *e*. The true vocal cords. *f*. Fold of mucous membrane.

Fig. 26. The Larynx seen from above by the laryngoscope during voice production.
a. Root of the tongue with taste papillæ and glands. *b*. Short tendinous band between the root of the tongue and the epiglottis. *c*. Upper surface of the epiglottis. *d*. Prominence of the inner surface of the epiglottis. *e*. Glottis. *f*. False vocal cords. *g*. True vocal cords. *h*. Top of the arytenoid cartilage. *i*. Band between the arytenoid cartilage and the epiglottis.

It has a funnel and ring-like appearance, and is made up of several pieces of cartilage which are covered and joined together by mucous membrane, and approximated to each other or separated by small voluntary muscles. The large cartilage known as Adam's apple can be felt under the skin of the neck, and can be seen to move in swallowing; it is called the thyroid cartilage; below this is the cricoid cartilage. On the hinder upper margin of this latter lies the arytenoid cartilage, and on the anterior upper margin of the thyroid is the epiglottis, attached by a small stalk; it forms a thin, heart-shaped cartilaginous plate which closes the entrance to the larynx when food and drink pass over the larynx directly into the gullet, which lies immediately behind.*

Epiglottis.

* If a drop of fluid or a foreign body, like a crumb of bread, pass into the air passage ("go the wrong way"), it is immediately forcibly coughed out again. Women and children have a smaller larynx and shorter vocal cords than men and adults, and therefore higher-pitched voices. In catarrh the mucous membrane of the vocal cords is swollen and covered with mucus; the movements are hindered, and roughness and hoarseness of the voice are produced. The same result follows paralysis of one of the laryngeal muscles.

The lips, the palate and teeth are concerned in the production of some sounds.

Vocal cords.

In the interior of the larynx, on its walls, lie the vocal cords horizontally, from before backwards; of these there are two upper false vocal cords, and just beneath them the two true cords. The former are folds of mucous membrane, and have nothing to do with the production of the voice; the latter are folds of mucous membrane extending from the anterior part of the thyroid to the arytenoid cartilages. The vocal cords of the right and left sides leave an elongated triangular space between them which is called the glottis. (IV. 32.)

Glottis.

Just over the larynx, and joined to it by fibrous bands, is a small horseshoe-shaped bone, the hyoid bone (IV. 28). When the head is bent backwards, this can be felt in the upper anterior part of the neck through the skin.

The larynx serves for the production of the voice, the height and depth of which depend on the number of vibrations of the true vocal cords. In order to produce a higher or lower tone, the glottis is narrowed or widened, the vocal cords become more or less tense, and are set in vibration by the air from the lungs passing through them.*

The degree of tension is produced by a number of small muscles, the laryngeal muscles, which are attached to different parts of the larynx. In quiet breathing, the glottis is moderately wide open.

In singing high notes the glottis is narrow, as may be seen by the laryngoscope, the vocal cords are brought near one another and tightly stretched. The tone is higher the quicker the vibrations follow one another. The vocal organ has great similarity to an organ pipe.

The Trachea.

The trachea (III. 3 and IV. 31), lies in the middle of the neck and runs downwards. It consists of 17 to 20 C-shaped cartilage rings placed one over the other, united by membrane. The posterior wall is formed of a muscular membrane. The length of the trachea in adults is about 9 or 10 centimetres; its diameter about $1\frac{1}{2}$ cms. At its lower

* On each side of the larynx lies the thyroid gland, partly adherent to it. This gland is frequently enlarged, and is then changed in structural character. The enlarged gland is called a goître. In some districts this disease is especially common.

Many diseases of the larynx are recognised by the laryngoscope. This consists of a small mirror mounted on a handle, which is passed through the mouth into the hindermost part of the mouth cavity, and turned downwards to an angle of 45 deg., so that the parts of the larynx and trachea lying beneath can be seen. Especial illumination is necessary. In a similar manner, with the mirror turned upwards, the nasal cavity can be illuminated and observed from behind.

part, on a level with the third dorsal vertebra, it divides into two great branches, which are called bronchi; these consist also of semicircles of cartilage which are united together by connective tissue and mucous membrane.

One of the bronchi branches into the right, the other into the left lobe of the lung. The trachea is lined with ciliated epithelium (Fig. 27), that is to say with cells which are covered with extremely fine hairs or cilia, which move from below upwards, whose duty it is to convey mucus and particles of dust outwards.

Fig. 27. Ciliated Epithelium (× 300). *a*. Cilia.

The Lungs.

The lungs (III. 13, a, b, c) consist chiefly of innumerable fine canals in which the branches of the air-tubes (bronchi), lose themselves by constant finer and finer branching.*

Action of the lungs.

The terminal branches have at their ends little cells consisting almost entirely of mucous membrane, which is surrounded on the outside by an extraordinarily fine network of blood-vessels. In breathing, all these countless † little structures are distended by the air entering them; it thereby comes into direct contact with the delicate blood-vessels.

In this way an exchange of certain gases is effected between the blood and air in such a way that the blood gives up to the air in the lungs those gases, especially carbonic acid, which have become useless for the nourishment of the body, and takes up those gases, especially oxygen, which are necessary for its nourishment. A large amount of moisture is also excreted by the lungs.‡

* This branching can be compared to nothing better than to the progressive branching of a tree.

† The number of these air cells is reckoned at 1,700 to 1,800 millions.

‡ An adult breathes out in one day through the lungs 800 to 1,000 grammes of water.

Plants take up carbonic acid during the day, that is, under the influence of sunlight, by means of their green parts, decompose it and keep the carbon which the carbonic acid contains. They give off oxygen, which man inhales, to the atmosphere. By night, in darkness, they breathe like men, that is to say they give up carbonic acid. Flowers and blossoms always breathe out carbonic acid in darkness as well as in light; it is prejudicial, therefore, to have plants, especially blossoms, in a sleeping room. In a dwelling room, however, plants with green leaves give off oxygen in the daylight, and are therefore an advantage to the inhabitants.

Structure. The lungs consist of two large spongy grey-red or blue-black firm bodies, whose weight is 1 to 1·25 kilogrammes. They have the form of cones with the apex directed

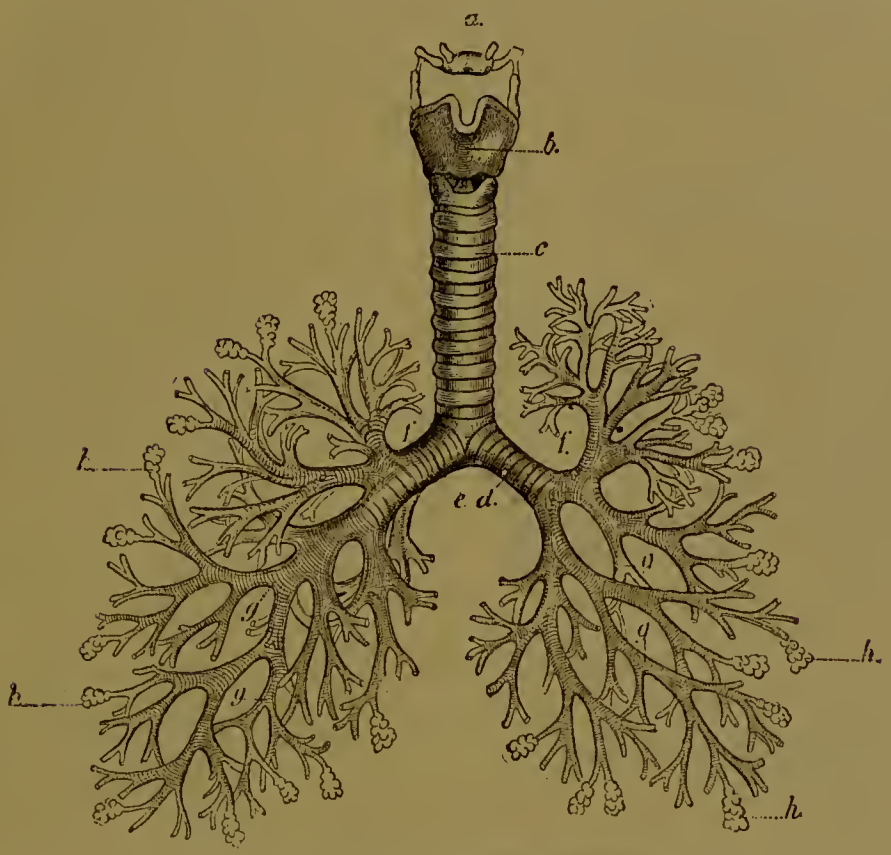


Fig. 28. Larynx, Trachea, Bronchi (diagrammatic).
a. Hyoid bone. *b*. Larynx. *c*. Trachea. *d*. Left bronchus. *e*. Right bronchus. *f.f*. Larger bronchi. *g*. Smaller bronchi. *h*. Cells of the lungs.

upwards, and fill the chest on each side of the spine. The base of the cone rests on the diaphragm.

Fig. 29. Air cells of the Lung and Bronchus.

The right lung is divided into three large distinct lobes lying one beneath the other; the left lung is divided into two lobes. They are known as two upper lobes (III. 13, a), two lower lobes (III 13, b), and one middle lobe (III 13, c). The heart is partly covered by the edge of the left lung; the lung contains no sensory nerves, but countless blood-vessels.

The blood-vessel which rises from the right side of the heart and carries blood to the lungs is called the *pulmonary artery*. The vessels which carry the blood back again are called *pulmonary*

veins; they are four in number, and empty themselves into the left side of the heart. *

Process of respiration.

In breathing, the chest is enlarged, the ribs are raised by the different muscles of the neck and chest (respiratory muscles), and the diaphragm is flattened downwards.

The lungs expand to an extent corresponding to this enlargement. Atmospheric air, consisting of oxygen and nitrogen, streams in, distends them, and fills them down to their finest cells. The air streams in and out of the chest just as in a bellows; also, in inspiration, the blood in those vessels which enter the chest is drawn inwards, and in expiration it is driven outwards. Respiration therefore promotes the flow of blood in the blood-vessels. After a time the muscles again relax, the lungs follow their action and contract, the chest is narrowed, and the inspired air is again driven out,† after its oxygen has been removed, and its carbonic acid given up. The expired air contains about 4 per cent. of carbonic acid, the inspired air, as a rule, only traces.

The number of respiratory movements in a healthy adult man is about 15 to 20 a minute,‡ in newborn babes about 40, and in children 24. In fever, with great bodily exercise, &c., the number

* In later life, or in consequence of too great effort, the lung becomes very much distended. Many of the cells become torn, and the lungs lose their elasticity; this diseased condition is called emphysema, and the difficulty of breathing associated with it is called asthma. In inflammation of the lung the mucous membrane of the delicate lung cells becomes inflamed and secretes a coagulating fluid which blocks the air cells and makes breathing in the inflamed part of the lung impossible. In consumption, or tuberculosis of the lungs, there is an inflammation of the lungs, the lung tissue is destroyed, and large cavities filled with pus are formed.

† This emptying is not of such a nature that all the air is driven out of the lungs; part always remains behind. It is necessary to breathe deeply in and out alternately, in order to get rid as much as possible of the spoilt air which remains behind in quiet breathing, and to replace it by fresh air.

‡ When a stethoscope is applied to the front or back of chest, the passage of air in and out of the lungs can be heard. The physician forms an opinion from these sounds whether the lungs are healthy or not. (Auscultation of the lungs). By percussion of the chest, the physician can determine the size and extent of the solid, that is to say *non* air-containing, organs (heart, liver, spleen), and separate them from the air-containing ones (lungs, intestines). One can also learn by percussion if the lungs are healthy and contain air or not. The supply of fresh and pure air is just as necessary for the good of the human body as food and drink. By deep breathing, by erect and proper carriage, the chest developes, its muscles increase in strength, and by living in the open air the lungs are well developed. By confining the chest, its movement is much impeded. In closed rooms, especially when many people live in them, the air becomes impure by the increase of carbonic acid, and it is therefore necessary to carefully ventilate such places. In deep respiration an adult breathes in about 3,400 to 3,500 cubic centimetres of air.

of respirations increases; more carbonic acid then collects in the blood, which must be removed as soon as possible, and replaced by oxygen.

The nerves which maintain breathing arise from the upper part of the spinal cord. Injuries of this part of the cord are followed by immediate death, because they interrupt the respiratory process.

II. The Vascular System (Organs of Circulation).

I. The Blood.

The blood is a bright or dark red sticky fluid with a salt taste, which flows through the blood-vessels and capillaries, and is distributed over the whole body; on the one hand it carries nourishment to the various organs, and on the other removes the materials which are no longer serviceable (bile, sweat, urine, &c.). The blood is in constant movement through the vessels; it flows from the heart through all the varied organs of the body, and back again to the heart (circulation of the blood).

Warmth and volume of blood.

The temperature of the blood is about 37·5° Celsius (=30° Reaumur=98·4° Fahrenheit).*

The amount of blood in an adult man varies very much, and is estimated from five to ten kilogrammes. It is usually reckoned at a quarter the body weight.

Serum and corpuscles.

Under the microscope countless little cells are seen in blood; they are called blood corpuscles (Fig. 30), and are suspended in a greenish-yellow fluid, the blood serum. The size of the red blood corpuscles and their appearance vary a good deal in different animals. The lower vertebrates, for example, have large oval corpuscles, birds have long oval corpuscles with a raised centre and sharp edge. Mammals have round disc-like corpuscles like man (only the camel, lama, and dromedary have oval ones).

In blood freshly caught from the veins, the corpuscles sink after a time, and a blood-clot separates from the serum.

The blood-clot consists of countless corpuscles and a mass of fine

* In febrile diseases the temperature rises to a considerable degree (40° to 41° C.); in cholera, after serious loss of blood, &c., it falls. Physicians measure the temperature by a thermometer, which is placed in the closed armpit of the patient.

All human beings, wherever they live, young or old, awake or asleep, fasting or not, have, as long as they are healthy, a constant temperature of 37·3° to 37·6° Celsius. Elevation or depression means impairment of health.

fibres (fibrin); this is originally fluid, it coagulates into fibres on cooling and falls to the bottom.

The serum of blood contains albumen and several dissolved salts.*

Arterial blood is rich in oxygen, bright red, and rich in nutritive material; *venous* blood is rich in carbonic acid, dark bluish-red, and poor in nutritive material.

Red and white corpuscles.

There are red and white blood corpuscles; the former largely exceed the latter in number (300 or 400 to 1).

Fig. 30. Blood Corpuscles.

a. Human white blood corpuscles, some with processes (× 800). *b*. Human red blood corpuscle (× 1000). *c*. Pigeon's blood corpuscles. *d*. Blood corpuscles of a frog (× 800).

When magnified 200 to 300 times the red corpuscles appear as yellow-red flat discs, somewhat depressed in the middle on each side. A single drop of blood contains many millions of them. The peculiar blood colouring matter is contained in them; this colouring matter is mainly due to an admixture with iron.†

* According to careful observations, 1,000 parts of blood contain—

Water	780·15	to	785·59	parts.
Fibrin	2·10	,,	3·56	,,
Albumen	65·09	,,	69·42	,,
Corpuscles	133·00	,,	119·63	,,
Crystallised fat	2·43	,,	4·39	,,
Fluid fat	1·31	,,	2·27	,,
Alcoholic extract	1·79	,,	1·92	,,
Watery extract	1·26	,,	2·01	,,
Alkaline salts	8·37	,,	7·30	,,
Earthy salts and oxide of iron	2·10	,,	1·41	,,

† In poverty of blood (anæmia and chlorosis), the number of red blood corpuscles is notably diminished, while the fluid parts are increased in quantity. Great loss of blood weakens strong men very considerably, especially if often repeated. In blood poisoning, poisonous materials, minute organisms (fungi, spores, bacteria, bacilli) are present in the blood stream, and change the blood material. In many diseases, anthrax, typhus, tuberculosis, &c., the disease-producing microscopic fungus has been identified with certainty.

The white corpuscles appear under the microscope as small round cells, containing one or more nuclei. They are carried into the blood with the lymph and chyle (p. 64). The white blood corpuscles are formed principally in the spleen, lymphatic glands, and bone marrow; they change in the blood-vessels into red corpuscles, and for the most part are destroyed in the liver. They are able to change their form; they often appear jagged, and have processes extending from them; they can penetrate the walls of the capillaries and wander in the surrounding tissues.

The blood flows in countless canals which run side by side, and are called blood-vessels.*

The centre of the vascular system from which the blood is driven into all parts of the body, as from a force-pump, and to which it again returns, is the heart.

II. The Heart.

The heart is a cone-shaped hollow muscle, with the apex directed downwards and to the left. It lies in the left side of the chest near the middle line. In adults its size is about that of a fist, and has a weight of about 350 grammes. It consists of countless longitudinal and transverse muscular fibres closely felted together. It is surrounded by the pericardium; this latter forms a closed membranous sac, which, like the peritoneum and pleura, belongs to the serous membranes—that is to say, to those which secrete moisture or fluid from their surface. The heart is placed in this sac in such a way that the upper part of the sac is closely adherent to the surface of the heart, while the remaining part surrounds the heart loosely without being adherent to it. It is only the base of the heart, its upper wide part, which is adherent to it. On its outer side the pericardium is united with the pleura and diaphragm.

Pericardium.

The heart is the central organ of the blood current, and in order to maintain it is in constant movement. It contracts about sixty to seventy times a minute in adults,† and thereby drives the blood into the arteries. After every contraction it dilates again in order to receive the blood

* If a blood-vessel or capillary is torn or crushed, a hæmorrhage or flow of blood is produced. This varies in size with the size of the vessel; it is especially dangerous when it arises from an artery in which the blood is contained under great pressure. In certain diseases (scurvy and purpura) the walls of the blood-vessels in the different organs are brittle and easily torn.

† In children the contractions of the heart are much quicker than in adults. In the former they amount to from 90 to 120 per minute. There are about four pulse beats to each movement of respiration. In febrile diseases the number of pulse beats is markedly increased. In fear, anxiety, &c., the contractions of the heart are quicker—palpitation is caused.

returning from the body through the veins. The contractions of the heart we recognise in the arteries as the pulse, and in the chest, between the fifth and sixth ribs on the left side, as the heart beat or impulse.*

The movements of the heart go on independently of our will.

The nerves of the heart are partly embedded in the heart muscle, and have very numerous ganglion cells in relationship with them. The heart has, to a certain extent, its own nervous system, and contracts, therefore, for a time after the other signs of life have disappeared. The heart has also other nerves which are connected with the brain and spinal cord by whose means the activity of the heart is altered through emotion, &c.

Structure of the heart.

The heart consists of two symmetrically placed, closely united halves, separated by a muscular partition.

The blood, which has become full of oxygen by its passage through the lungs, is received by the left half of the heart which distributes it to the whole body, while the right half receives the blood coming from the body, no longer rich in oxygen, and drives it into the lungs in order to purify it again.

Each of the above-mentioned halves of the heart is divided again into two chambers, an auricle and a ventricle, which are connected with each other but not with the cavities of the other side of the heart.

There are thus four chambers in the heart, two auricles and two ventricles.

The auricles.

The auricles are the two upper divisions of the heart, they have much thinner walls than the ventricles. Into the left auricle the four pulmonary veins bringing the blood from the lungs, empty themselves. The two large veins, the superior and inferior venæ cavæ, bringing the blood back from the whole of the body, empty themselves into the right auricle.

The ventricles.

The ventricles form the lower two-thirds of the heart, they have much thicker walls than the auricles. The wall of the left ventricle is again thicker than that of the right. Both chambers are separated from each other by a thick muscular partition. The partition between the auricles is very much thinner. Each auricle is united with its underlying ventricle by a moderately wide oval opening, which can be closed by a valve† in such a way that the blood can pass into the ventricle when the auricle contracts, but cannot pass from the ventricle to the auricle on contraction of the former.

* Physicians count the pulse in the forearm near the wrist, because an artery lies close under the skin here and can be easily felt.

† These valves consist of several flat, triangular membranes, which are firmly attached at the edges of each opening by a broad base between the auricle and the ventricle. On the left side they are three in number, on the right two. Their free

From the left ventricle arises the great artery of the body (aorta, III. 7). From the right ventricle arises the pulmonary artery (III. 11). The reflux of blood from these vessels to the ventricles is prevented by pocket-shaped valves.*

Movements of the heart.

The mechanism of the heart movements is the following :—

The two auricles filled with blood contract simultaneously, and drive the blood into the ventricles.

While each of them expands again in order to receive fresh blood, the ventricles contract and drive the blood into the aorta, and pulmonary artery.

The channels in which the blood flows to and from the heart are :—

III. The Blood-vessels.

These are divided into arteries and veins.

The blood-vessels are membranous tubes, which, as a rule, consist of three delicate flexible layers—an outer connective tissue layer, a central muscular layer, and a very thin inner cellular layer.†

edge projects into the cavity of the ventricle, having a large number of thin tendinous fibres passing from the edge to conical projections of muscle from the wall of the ventricle.

As soon as the ventricles contract the valves are stretched by the blood pressing against them, and as their edges come into contact they close the opening between the auricle and ventricle, and so prevent the backward flow of blood into the auricle. The blood must constantly move forwards.

* They are three in number, and resemble small membranous pockets with semi-lunar edges, which are firmly attached to the inner surface of the aorta and pulmonary artery. They open in a direction away from the heart with the blood current ; they prevent the reflux of the blood from the pulmonary artery and aorta into the ventricle. When the blood rushes backwards during the relaxation of the auricles, the auriculo-ventricular valves become distended and closed. At times, especially in acute joint rheumatism, the valves become inflamed, in consequence of which they shrink together, and do not ensure the necessary closure, so that the blood flows backward. The heart muscle is enormously strained in order to drive the blood forwards, it thereby increases in size, and the cavities also become dilated. In this manner dangerous heart-defects arise. The closure of the valves causes a musical sound. If the valves do not close, a singular sound is produced. In order to ascertain the condition of the heart-valves, physicians listen in the neighbourhood of the heart, and thus form an opinion on it—that is to say, the normal or abnormal condition of the heart, especially of the valves.

† In old age the walls of the arteries frequently become calcified, and are hard and unyielding. As a consequence they rupture, and the blood escapes into the surrounding tissues. If an artery ruptures in the brain, either sudden death occurs, or paralysis of the extremities (arms, legs), or face muscles, speech, &c., according to the situation and extent of the hæmorrhage. This occurrence is known as a *stroke* or *fit* of *apoplexy*.

The walls of the arteries are considerably thicker and more elastic than those of the veins.*

Arteries. The arteries, as a rule, are deeply seated, and protected or covered by muscles; they contain bright red oxygenated blood, and convey it to all parts of the body. They constantly divide or branch up into finer branches or twigs, just as a tree does.

Veins. The veins lie for the most part near the surface; they can be generally seen beneath the skin as blue lines, or they accompany the arteries, one on each side. They contain dark cherry-red blood, rich in carbonic acid. The veins arise by fine twigs and branches in those parts of the body in which the small arteries branch. These fine branches unite into larger veins, and finally form two large veins, the two venæ cavæ (III. 12), which empty the blood from the whole body into the heart. In the larger veins there are semi-lunar membranous valves, which open towards the heart as in the aorta and pulmonary arteries; these prevent the reflux of blood towards the periphery (Fig. 31).

Fig. 31. Vein laid open with half-moon-shaped valves attached to its walls, *a.a.*

Between the fine terminations of the arteries and the smallest veins are the capillaries, which maintain an unbroken connection between the arteries and veins.

The capillaries. The capillaries form an extraordinarily fine dense network of delicate hair tubes in almost all the organs of the body; they are invisible to the naked eye, and consist of a single extremely thin transparent membrane, similar to the inner coat of the larger vessels.

Interchange of material. In the capillaries the interchange of material between the blood and tissues for nutritive purposes takes place in such a way that the nutritive material, carried by the arteries to the capillaries, passes through the thin walls of the latter into the different organs of the body. On the other hand, the used-up

* The arteries gape when they are cut across, while the veins collapse. Partly for this reason, and partly because the blood, in consequence of the pressure to which it is subject, rushes through the arteries with greater force, an injury to an artery is much more dangerous than to a vein. In order to stop bleeding from an artery temporarily, pressure must be applied to the artery nearer the heart than the seat of the injury. The surgeon applies a ligature to the cut ends of the artery to stop the bleeding permanently.

material is again taken up by the capillaries and conveyed to the veins.*

IV. The Circulation of the Blood.

We have already stated that the blood gives up in the capillaries its nutritive material into the surrounding tissues, and that the latter constantly need this material for their nourishment.

In order that fresh nutritive blood should be constantly present in the tissues it is kept flowing through the capillaries; this flow to and from the heart is called the circulation of the blood.

The prime cause of this blood movement is the heart.

The course which the blood takes in its circulation is the following (Fig. 32).

The bright red arterial blood pours from the left ventricle swiftly through the large arteries of the body which branch up continuously into the finest arterioles. The blood passes much more slowly from these last finest arterioles into the capillaries, in which it gives up a portion of its nutrient substance, especially oxygen.

Greater circulation.

Fig. 32.

a. Left ventricle. *b*. Right ventricle. *c*. Left auricle. *d*. Right auricle. *e*. Aorta. *f*. Capillaries in the different organs of the body uniting arteries and veins. *g*. Veins. *h*. Pulmonary arteries. *i*. Capillaries of the lung. *j*. Veins of the lung. *e.f.g*. Greater circulation. *h. i. k*. Smaller circulation.

From the capillaries it passes as dark red blood into the finest veins, and returns by means of the veins, which constantly enlarge as they approach the heart, till it is emptied through the venæ cavæ into the right auricle.

The portion of the circulation just described is called the *Greater Circulation*. In the greater circle of the blood current between the aorta and the inferior vena cava is another included system of capillaries, the Portal System, described on page 51.

From the right auricle the blood passes with each contraction into the right ventricle, and hence through

* In inflammation, the capillaries are much distended, the affected part appears red; fluid and white corpuscles pass through the walls of the capillaries into the parts around the vessels. These are called exudations. Pus in this way arises from the blood, and consists in great measure of white blood corpuscles.

the pulmonary artery to the lungs.* In the lung the blood passes into countless branches and capillaries which surround the air cells; it there comes into contact with the oxygen of the inspired air. From the lungs the blood, which has now become bright red and rich in oxygen, returns by the four pulmonary veins† to the left auricle; by contraction of the auricle it passes to the left ventricle, hence into the aorta, and so into the greater circulation.

Lesser circulation.

The second part of the circulation, that which is carried on through the lungs, is called the *Lesser Circulation.*

III.—The Organs of Digestion and Accessory Organs.

The digestive canal, from its beginning in the mouth and gullet to its end in the rectum, consists of a membranous canal, which varies in size, and is lined throughout with mucous membrance. (III. 24–27, and 32–36.)

I. The Mouth, Gullet, and Stomach.

In the mouth (Fig. 33) are contained the teeth, firmly fixed in the upper and lower jaws behind the lips (already described on page 16). The space between the cheeks and teeth is called the buccal cavity. Into this space saliva from the parotid gland empties itself (see p. 53). In mastication the food is thoroughly moistened by the saliva, its starchy constituents are dissolved and partly digested. The tongue lies on the floor of the mouth; the palate forms its roof. In its anterior part this is hard and formed by the upper jaw and palate bone, in its posterior part it is soft. If the tongue is depressed at the back of the mouth a movable membranous curtain can be seen hanging down, the *soft palate*, and in the middle line attached to its lower edge is the *uvula*. On each side the arches of the palate can be seen, soft folds of mucous membrane, between which on each side lie the tonsils. Behind the uvula and arches of the palate

Fig. 33. Mouth cavity, mouth opened. *a.* Upper lip. *b.* Lower lip. *c.* Tongue. *d.* Palate *e.* Uvula. *f.* Posterior pillar of the fauces. *g.* Anterior. *h.* Tonsil. *i.* Pharynx. *k.* Epiglottis.

* The pulmonary artery is the only artery which does not contain bright red arterial blood; it contains dark venous blood.

† The pulmonary veins are the only ones which contain bright red arterial blood.

lies the pharynx, a muscular tube which forms the upper part of the gullet. At its upper and posterior part the mouth cavity lies in relationship with the nasal cavity and the *Eustachian Tube* (p. 85).

The gullet.

The *Gullet* or *Œsophagus* has a length of from 18 to 21 centimetres, and consists, like all parts of the digestive canal, of an outer covering, the fibrous coat, a middle muscular coat, and an inner mucous coat. It lies collapsed in longitudinal folds immediately behind the larynx and the trachea, and is capable of considerable enlargement. In swallowing solid food the walls contract above the morsel and drive it down to the stomach. In the chest the œsophagus lies at first on the spine, and lower down, on its left side, until it passes through an opening in the diaphragm, and

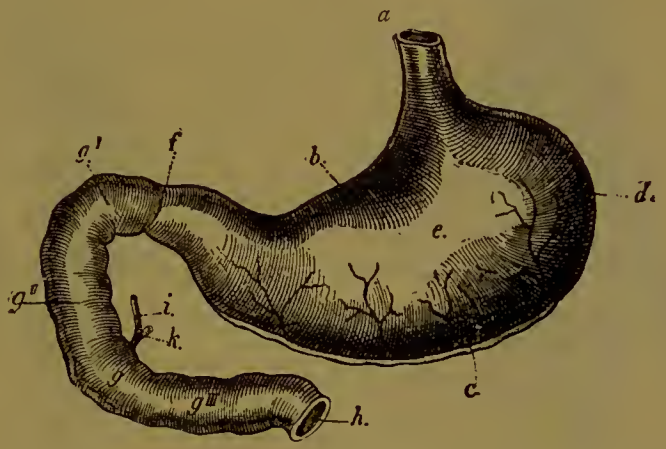


Fig. 34. Stomach and Duodenum.

a. Œsophagus, lower part. *b*. Lesser curvature. *c*. Greater curvature (an artery running along it). *d*. Fundus. *e*. Anterior wall. *f*. Pylorus (transition between stomach and intestine). *g*. Duodenum. *g'*. First portion. *g''*. Descending portion. *g'''*. Transverse portion. *h*. Commencement of jejunum. *i*. Common bile duct. *k*. Pancreatic duct. The two latter unite before their entrance into the duodenum.

opens into the stomach on the left side. The opening of the œsophagus into the stomach is called the cardiac orifice of the stomach.

The stomach.

The stomach (III., 25, Fig. 34) presents a wide curved sac, which is placed in the upper part of the abdominal cavity transversely from left to right, immediately under the diaphragm. It consists, as already mentioned, of three membranous layers, of which the muscular layer, formed of muscular fibres running in different directions, is the cause of the movements by means of which the food mixes with the gastric juices, and is carried on after a time into the adjoining intestine. The food mixed with the digestive juices is called chyme.

The stomach possesses, therefore, two openings : the cardiac orifice, which lies at the left upper part of the stomach, indicates the place of entrance of the œsophagus (III. 24). The pylorus (III. 26) is the opposite orifice on the right side, leading into the duodenum. Food

passes in by the cardiac entrance, out by the pyloric.* Both, especially the pylorus, are surrounded with circular bands of muscular fibres; by their contraction the stomach can be closed above and below. On the left side the stomach forms a sac-like expansion, which is called the fundus. This is bounded on the left side by the spleen, and is united to it by the peritoneum. On the right side, towards the pylorus, the stomach becomes narrower, and is here partly covered by the liver. It is capable of great distension, and in many adults can hold four to five litres of fluid.

Fig. 35. Compound gland of the stomach. *a*. Common excretory duct. *b*. Gastric glands.

Fig. 36. Tubular gland of the stomach. *a*. Peptic gland (× 300).

The mucous membrane of the stomach is unusually thickly set with digestive glands, that is, with little tubular, sometimes branched depressions, simple and branched stomach glands (Figs. 35 and 36). In these the gastric juice is secreted from the blood, especially when the mucous membrane is stimulated by food entering.†

The gastric juice is a transparent clear fluid, with a strong acid taste, especially designed for the solution and digestion of albuminous

* Sometimes very forcible contractions of the stomach occur, by which food is driven back into the œsophagus, producing retching and vomiting. Sharp objects, such as fish bones, easily remain sticking in the œsophagus. They can generally be removed by the finger, or vomiting can be excited by tickling the palate.

† Inflammation of the mucous membrane of the stomach, in which digestion is frequently interrupted, is called gastric catarrh. This disease is very easily acquired by the free use of very cold water, or by excessive eating. Sometimes ulcers arise in the stomach, which destroy the blood vessels of the stomach wall, give rise to hæmorrhages, and even lead to perforation of the stomach-wall. Fluids are very

food, especially meat. It is reduced to a fluid condition, in which it can be taken up by the blood vessels.*

II. The Intestinal Canal.

The duodenum.

The intestinal canal is joined to the stomach, and is in adults about seven metres long. It is divided into several parts :—the duodenum (III. 27); the jejunum; the ileum (III. 32); and the large intestine (III. 34 to 36). The duodenum is that part of the intestine which receives the food from the stomach through the pylorus. It is shaped like a horseshoe, with the convexity to the right, and has a length of about 12 fingers' breadth. The *Pancreas* lies in the concavity.

The united ducts of the gall bladder and pancreas empty themselves into it. From time to time bile and the secretion of this latter gland pour into the duodenum and mix with the chyme for the purpose of digestion, especially of fat.

The jejunum and ileum, which are the continuation of the duodenum, measure together in the adult about 5 to 5·5 metres. They form a tube of many coils, which come into view at once on opening the abdomen of any large mammal.†

Villi.

The small intestine is very thickly lined on its inner surface with fine glands, which lie together in many places in considerable numbers. By means of innumerable fine fibres or *villi*, which project like millions of small roots into the digested food, the parts of the food suitable for nutrition are absorbed and passed into the blood.

A small canal is contained in each villus, in which the nutritive

quickly absorbed by the healthy stomach. We see it, for example, in the rapid action of poisonous substances when these are brought in a fluid form into the stomach. Solid foods, especially those which should be first dissolved by the gastric juice, often lie for many hours in the stomach before they pass on. In sedentary occupations digestion is slow, quicker with moderate movement and during waking hours. Absolute rest (sleep) and strong movements delay digestion.

* In consequence of the strongly acid nature of the gastric juice, and also on account of the high temperature in comparison with the temperature of the air, it is impossible for animals swallowed alive, like frogs and snakes, to continue to live in the stomach. All stories relating to this belong to the category of fables.

† The abdominal wall is not uniformly thick all over; in certain places there are gaps in it which have scarcely any covering but skin. Sometimes a portion of intestine passes into and through such a gap immediately beneath the skin. This constitutes a rupture (hernia). If the loop of intestine cannot be put back the hernia becomes strangulated. By a suitable truss the escape of the intestine is prevented.

Animals which live on flesh have a shorter intestine than those which live on vegetable foods.

material absorbed from the chyme, and then called *chyle*, is collected and passed onwards.

These canals, the beginnings of the Absorbents (see p. 64), grow wider, and pass on the chyle, as well as the dissolved fats and albuminous

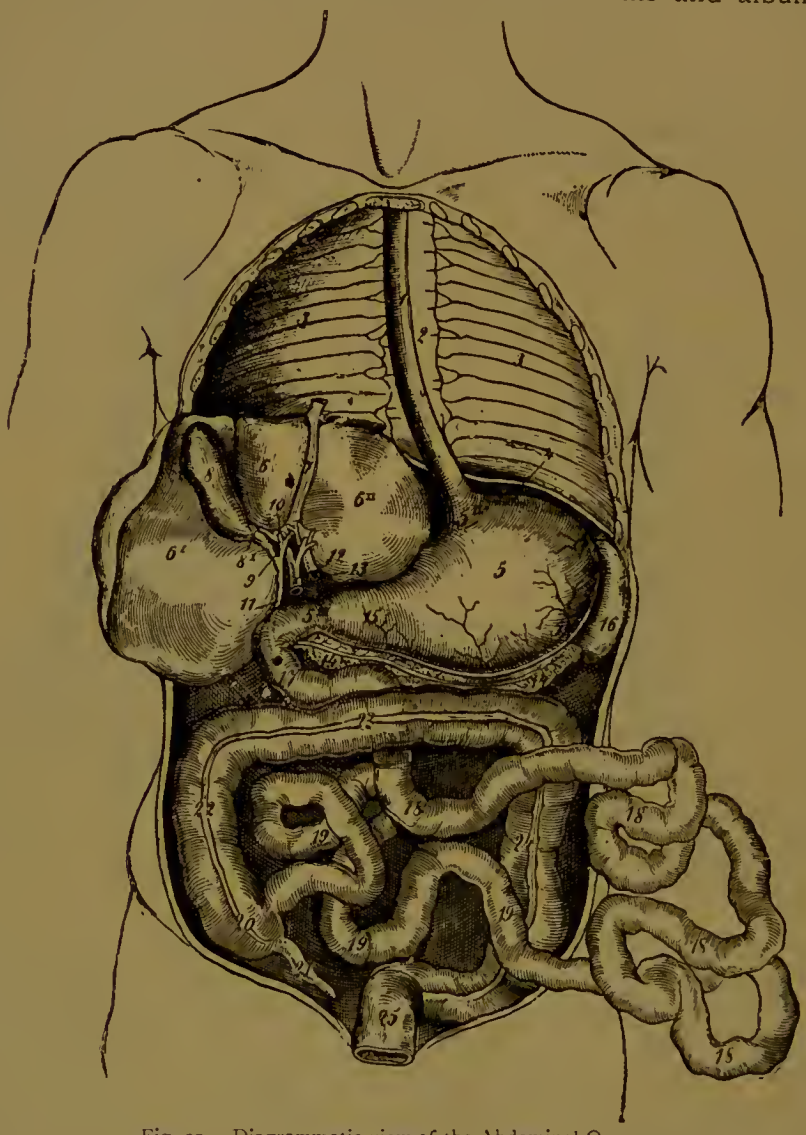


Fig. 37. Diagrammatic view of the Abdominal Organs.

1. Œsophagus. 2. Spinal column. 3. Ribs. 4. Diaphragm. 5. Stomach. 5′. Fundus of the stomach. 5″. Cardiac orifice. 5‴. Pylorus. 6. Liver turned upwards. 6′. Right lobe of liver. 6 . Left lobe of liver. 7. Suspensory ligament of liver. 8. Gall bladder. 8′. Neck of gall bladder. 9. Gall duct 10. Hepatic duct. 11. Common bile duct. 12. Portal vein. 13. Hepatic artery. 14. Pancreas; 15. Pancreatic duct; empties with the common bile duct into the duodenum. 16. Spleen. 17. Duodenum. 18. Jejunum. 19. Ilium. 20. Cæcum. 21. Vermiform appendix. 22. Ascending colon. 23. Transverse colon. 24. Descending colon. 25. Rectum.

materials through the mesenteric glands into the large lymph vessels or lacteals, and finally into the Thoracic Duct, which empties itself into the superior vena cava. The salt and sugar containing part of the chyle, pass into the blood vessels of the intestinal wall, thence to the liver through the portal vein (see p. 51), and finally into the inferior vena cava.

Large intestine.

The large intestine, which comes next to the small intestine, is from 1·2 to 1·4 metres long, and contains no villi. At the junction between the large and small intestines is a fold of mucous membrane, the Ileo-cœcal valve, which projects about 1·2 cm. into the intestinal cavity, and has in it a wide gap, which allows the contents of the intestine to pass downwards but prevents the return of food contents from the large to the small intestine.

Cœcum and vermiform appendix.

The first part of the large intestine is called the Cœcum ; this is a long blind sac, several centimetres long, placed in the right lower part of the abdominal cavity. The cœcum varies in size in different animals.

At the blind end of this sac is a worm-shaped hollow process, 5 to 7 cm. long and 5 to 7 mm. thick, whose cavity is joined to that of the cœcum ; it is called the Vermiform Appendix*

Colon.

The middle part of the large intestine, about 1·2 metres long, is called the Colon. Its wall is thick, and crossed at frequent intervals by transverse bands. According to its position it is called the ascending, transverse, and descending colon.

Its course is upwards on the right side of the body, it makes a bend just beneath the liver, runs then along the under surface of the liver and stomach transversely to the left, turns downwards on the left side of the body, and ends by an S shaped curve (the sigmoid flexure) in the third part of the large intestine, the rectum.†

The rectum.

The Rectum is about 14 cm. long ; it has a very strong muscular coat, and runs along the inner surface of the Sacrum downwards and outwards. The longer the chyme remains in the large intestine the poorer it is in fluid and nutrient materials. In the large intestine it acquires a firm, dry character, and consists almost entirely of indigestible, insoluble, and useless material. The time of passage of food through the whole intestinal canal is about fifteen hours.‡

* Ruminants, animals who chew the cud, have a very long cœcum. In the cœcum, and especially in the vermiform appendix, the remains of food, like cherry stones, sometimes become fixed, and cause great and dangerous inflammation and perforation of the intestinal canal.

† There is a special kind of affection of the large intestine called dysentery.

‡ The small intestine has very little sensation, the large intestine has very many sensory nerves. By spasmodic contraction of the large intestine the pain known as colic is produced. The blood vessels of the rectum are called hæmorrhoidal vessels.

Many parasitic worms live in the intestinal canal, the most troublesome of which are *tape*-worms. The different kinds of tapeworm are known as Tænia solium, Tænia medio canellata, and Bothriocephalus latus ; the last is very rare in England. The tapeworm is developed from a *cysticercus*, which is a small bladder the size of a pea, in the interior of which the larva of the tapeworm lies (p. 79). The cysticercus

III. The Liver and Gall Bladder (III. 15A and B, 17).

Liver.

The Liver, a glandular organ, is especially concerned in the formation of bile, an important fluid for the digestion of food, as well as in the purification of the blood. It is held in place partly by a very strong tendinous band, the suspensory ligament, which is attached to the diaphragm. The liver lies in the upper right-hand part of the abdomen, and weighs about 2·5 to 3·0 kilogrammes. Its transverse diameter in adults is about 24 to 28 cm., its antero posterior diameter 16 to 20 cm., and its thickness about 6 to 8 cm.

On the left side it touches the stomach; its upper surface is in contact with the diaphragm, its under surface with the small intestine, and especially with the transverse colon.

External structure of the liver.

The liver is divided into several lobes by two longitudinal and one transverse fissure on its under surface, which form a letter H; the transverse fissure is called the portal fissure. The hepatic artery (III. 22) and the portal vein (III. 21) enter the liver here. The gall bladder lies in the right longitudinal fissure. In the left fissure there is a strong band, which leads to the navel.

The liver is divided into right and left lobes (III. 15 *a* and 15 *b*); the former is considerably larger than the latter.

Internal structure.

The substance of the liver is a brown-red colour, very rich in blood-vessels, and on section seems to be made up of innumerable fine lobules.*

In the fine lobules, which consist of separate small microscopic cells—*the liver cells*—the bile is secreted from the blood, and is conveyed to the gall bladder or directly into the intestine by fine bile ducts, which unite to form larger canals, and finally unite in a single canal, the hepatic duct (III. 19).

of the Tænia solium is found chiefly in pork, that of T. medio canellata in beef; that of Bothriocephalus latus is not yet known: it probably grows in certain fishes. If man eats pork or beef containing cysticerci, the corresponding worm develops in his intestine. If the pig or ox eats portions of a tapeworm, which always contain innumerable eggs, it will have cysticerci. The round worm (Ascaris lumbricoides), and the threadworm (Oxyuris vermicularis) also inhabit the human intestinal tract.

The figures (pp. 78 and 79) give an idea of the form and size of the different intestinal worms.

* In the human liver parasitic worms are sometimes found, such as the great bladder worm (Echinococcus). People acquire this dangerous parasite when they by chance swallow with their food the eggs or segments of the tapeworm (tænia echinococcus), which is frequently present in dogs. There is also found at times in the liver the Distoma hepaticum and the Pentastomum denticulatum, the larva of the Pentastomum tænioides, which occurs in the nasal cavity of dogs.

The blood is purified from useless material in the liver; in addition, many blood corpuscles are destroyed here; they are dissolved, and afford material for the preparation of bile. The blood which flows from the liver is purer, and contains fewer old red blood corpuscles than the blood which enters.

Portal system.

Special mention must be made of the Portal Vein (III. 21) and the Portal System. We have already noticed that all the blood, after it has passed through the capillaries of an organ and has lost its nutrient properties by giving them up, is conveyed back to the right auricle of the heart by the veins as venous, carbonic acid containing, blood.

From this rule there is only one exception. The blood which has served for the nutrition of most of the organs of digestion, that is to say, of the stomach, part of the intestine, pancreas, spleen, &c., does not return directly to the heart, but is collected into a large vein called the portal vein, which enters the liver by the portal fissure, and divides up into very fine branches in the liver substance.

After it is distributed in the capillaries which surround the lobules and cells of the liver with a thick network, and after the bile is separated from it in the finest bile ducts, the purified blood is again collected in the hepatic veins and taken back to the heart. The blood of the hepatic veins, therefore, has passed twice through a capillary system before reaching the heart.

Branches from the aorta in the abdomen go to the stomach, intestines, spleen, pancreas, &c; these divide into finer branches, and finally reach the capillary network in these organs. Also, small veins from these organs run together, and finally unite into the portal vein. The porta vein enters the portal fissure, divides into fine branches in the liver finally into a capillary network, and after the bile is removed from the blood small veins form from the capillaries which unite into the great hepatic veins; these empty themselves in the inferior vena cava, and the blood now reaches the right auricle of the heart.*

Gall bladder.

The gall-bladder (III. 17), in the adult is about 8 to 10 centimetres long. It is a pear-shaped membranous sac, lying in the right longitudinal fissure on the under surface of the liver, and serves as a containing organ for the bile. After the flow of bile is excreted, it is conducted by the hepatic duct (a membranous canal in which the fine bile ducts from all parts of the liver

* Obstructions in the portal venous system occur very commonly; from this there results an accumulation of unhealthy blood in the liver, stomach, spleen, and intestines, and this leads to various diseases of these organs.

empty themselves), partly into the gall-bladder, partly through the common bile-duct, straight into the duodenum.*

The gall bladder has in its wall smooth muscular fibres, by means of which it contracts at times, especially during digestion, and when pressed upon by the abdominal muscles. It thereby empties its contents, at any rate in part, into the intestines, so that they mix with the chyme for the purpose of digestion. The upper narrow part of the gall-bladder is called its neck.

Bile.

The bile is a very bitter, more or less thick, green or dark-yellow fluid which is especially adapted for the digestion of fat and fat-containing foods. It acts on them in such a way that they can be absorbed by the blood. Sometimes hard stony concretions separate from the bile in the gall-bladder (gall-stones); they consist chiefly of cholesterin and bile pigment, and frequently block up the excretory ducts and give rise to inflammations and attacks of acute pain. If in this or any other way the flow of bile into the intestine is obstructed, for example, by closure of the bile duct with mucus in catarrh of the stomach and intestine, the bile passes back into the blood and jaundice is produced.

IV. The Glands.†

Glands in general.

By glands are understood organs which differ largely from each other in size and structure as well as in function, and indeed only present a few characters in common; they are distributed in almost all parts of the body, have a rich blood supply, but possess hardly any nerves of sensation. The glands present in general various large rounded structures which consist of innumerable blood-vessels and canals (excretory ducts).

The glands present the appearance of rounded bodies of different sizes made up of blood-vessels, secreting cells and excretory ducts.

The function of the glands is either to prepare certain fluids and to convey them by their ducts to the surface and into the cavities of the body, or to bring about certain changes by combination in the blood and in the fluids by means of their peculiar activity. These last glands possess no excretory ducts.

They are divided into excretory glands with ducts to which the

* The excretory duct of the gall-bladder is called the cystic duct. It unites with the hepatic duct to form with it a common bile duct (III. 20), leading to the duodenum. The bile consists of water, bile acids, cholesterin, &c., and of a yellow and green colouring matter.

† The largest glands lie in the abdomen—the spleen, pancreas, &c.

mucous, sweat, and sebaceous glands, lacrimal and salivary glands, pancreas, liver, and kidneys, belong, and into vascular glands which have no excretory ducts, to which the lymphatic and mesenteric glands, the spleen, the supra renal, thyroid glands and tonsils belong. They are also divided into simple and compound.

The simple glands consist merely of small flask-shaped or slightly-branched depressions in the skin, or mucous membranes, whose wall is lined with cells or epithelium. These have been already spoken of as mucous and sebaceous glands.

The compound glands are larger than the former, and possess a varied and very complicated structure.

Of the various glands we especially note—

Pancreas.

The pancreas (III. 23). This has a length of about 16 to 19 centimetres, and a diameter of 1·5 to 2 centimetres It lies in the upper part of the abdomen transversely along the lower part of the stomach; it reaches to the spleen on the left side, and is surrounded by the horseshoe-shaped duodenum on the right.

It consists of a large number of yellow-red lobules, through the middle of which runs a canal, the excretory duct, which collects the fluid excreted by the separate lobules and leads into the duodenum. The fluid excreted from the pancreas mixes with the chyme and bile and plays an important part in digestion, as, together with the fluid from the salivary glands of the mouth, it digests starchy food, to make it easily absorbed by the blood.

Salivary glands.

The salivary glands of the mouth form the saliva necessary for the digestion of starchy foods; there are two parotid glands,* two submaxillary, and two sublingual glands—one on each side.

The parotids are the largest of the salivary glands; they lie beneath the skin, in front of and under the ear, behind the cheek. The saliva secreted by them is conveyed by a thick duct into the mouth through a hole in the cheek.

The *submaxillary* glands are about half the size of the parotids, and lie on the inner surface of the lower jaw. These glands, like the sublingual glands, which have a similar structure, pour saliva by their ducts into the mouth.

Mesenteric glands.

In the abdomen, in addition to the pancreas, the mesenteric glands deserve mention. These lie buried in fat in the mesentery between the two layers of the peritoneum which attach the intestine to the posterior abdominal wall.

* Inflammation and swelling of the parotid occur sometimes epidemically. The cheek and region under the ear are very much swollen in this painful disease. It is called parotitis, or by its common name, mumps.

They are small round bean or lentil-sized vascular bodies which have a vessel containing chyle passing through them. By this means the chyle absorbed by the villi from the chyme in the intestine, which has a milky colour and appearance, is brought into intimate relation with the blood.

By this means an exchange of certain substances between the blood and chyme takes place, and the refined chyle is then conveyed on by the part of the duct leading away from the gland.

Lymphatics and lymphatic glands.

A system of fine ducts, or channels, and glands similar to that just described in the mesenteric glands is found in almost all the organs scattered through the body. These small canals are called *lymphatics*, and the glands in connection with them *lymphatic glands*.*

These lymph channels, like the chyle or lacteal vessels, are thin walled tubes like the veins, and contain valves which increase in diameter towards the heart. The valves are intended to prevent the reflux of lymph. The function of the lymphatics is to take up the surplus nutritive material which has been poured out from the capillaries into the surrounding parts of the body, and is no longer of use for nutrition, and to return it again to the blood.

The clear yellow-white fluid contained in the lymphatics is called lymph. The lymphatic glands, which are about the same size as the mesenteric glands, have also an afferent and efferent lymph vessel.

The united lymphatic and lacteal vessels, like the veins, run towards the heart, and finally unite into two large common ducts about the size of a crowquill, the thoracic ducts, which empty themselves into the subclavian vein on each side. In this way the blood is enriched with fresh nutritive material. The white blood corpuscles have their origin for the most part in the lymphatic and lacteal vessels and their accompanying glands.

The thyroid gland and the tonsil have a certain resemblance to

* The lymphatic vessels and glands are frequently the seat of acute and long-continued chronic inflammation. The glands often become much swollen, for example, in scrofula, tuberculosis, &c., so that they can be felt as large, hard knots on each side of the neck. The fluids necessary for nutrition are then conveyed to the heart in insufficient amounts, or of improper quality, and general impairment of health follows.

The lymphatic glands are also intended to retain harmful materials, and to prevent their entrance into the blood. In inflammation and suppuration of a finger for example, the lymphatic glands at the elbow and in the armpit become swollen.

Swelling and hardness of the thyroid is called goître. In many countries (Switzerland, for instance), this disease is very common. Swelling and inflammation of the tonsil is called tonsillitis or quinsy.

lymphatic glands. The former lies on each side of the larynx, the latter at the back of the mouth in two cavities, one on each side formed by the soft palate. The tonsils are round bodies about the size of a cherry, without ducts, and are frequently the seat of inflammation. Like the thyroid gland, they appear to play a certain part in the elaboration of the blood.

Thyroid gland and tonsil.

V. The Spleen (III. 28).

The spleen, a gland which has no excretory duct, lies in the left upper part of the abdomen on the left side of the stomach, covered by the last* four false ribs, and also partly by the diaphragm.

Fig. 38.
a. Hilus. *b*. Splenic vein. *c*. Splenic artery.

It is about 12 cms. long, 7 to 9 cms. wide, and weighs about 300 to 400 grammes. It has a semi-oval shape. The surface, which is directed outwards, is smooth and convex. The inner surface, directed towards the stomach wall, is concave. The nerves, blood-vessels, and lymphatics pass in and out here.

The substance of the spleen is a dark violet colour, is moderately soft, and consists of numerous blood-vessels and lymphatics. The spleen is the chief manufactory of the white blood corpuscles. The strong outer covering of the spleen is called the capsule.

The spleen is an important organ for the cleansing and preparation of the blood, and it is highly probable that the blood corpuscles are chiefly formed in the spleen, and are carried by the splenic veins into the general body of the blood.

VI. The Kidneys† (III. 29).

The kidneys are two brown-red coloured bodies, placed on each side of the upper lumbar vertebræ, just under the liver, the left one partly under the spleen. They are about 9 cms. long, 5 to 6 cms. wide, and 3 to 3·5 cms. thick. They are covered by a mass of fat and by a

* In many diseases, especially in typhus, ague, &c., the spleen becomes much swollen, and can be felt under the left arch of the ribs; also, after eating, the spleen becomes temporarily swollen.

† The kidneys have a double function, to remove the superfluous water and to form also a medium for the elimination of useless and harmful substances from the blood, especially urea and uric acid. If the excretion of these substances is diminished, so that the latter remains in the blood, various diseases arise, such as gout, uræmia, &c. In inflammation of the kidney, excretion of water, urea, and

strong fibrous membrane, the capsule, which is united to the surface of the kidney.

The surface of the kidney is smooth, its outer border is convex, its inner border concave. The renal arteries, veins, and ureter enter at the concave border.

The kidney substance is very vascular; it is divided into a peripheral cortical substance and an inner medullary substance.

The medullary substance consists of a number of pyramidal-shaped radiating cones, the pyramids, which are placed with their broad bases outwards towards the surface, with their apices inwards towards the concave border. They are made up of little tubes and

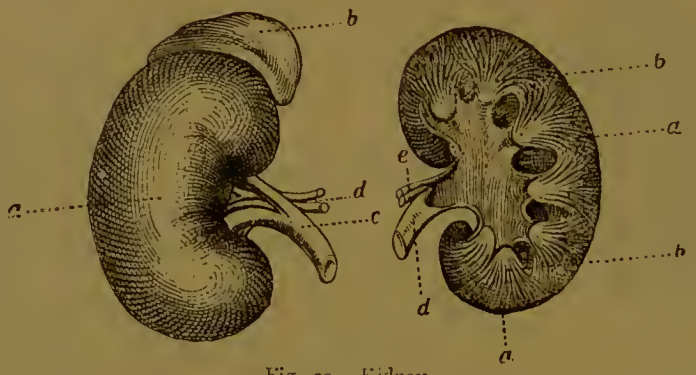


Fig. 39. Kidney.

a. Kidney in its capsule. *b*. Supra renal body. *c*. Ureter. *d*. Bloodvessels of the kidney.

Vertical section of kidney. *a*. Cortical substance. *b*. Pyramids. *c*. Pelvis. *d*. Ureter. *e*. Bloodvessels.

blood-vessels running in a straight direction, and only recognised under the microscope. The tubules (little tubes) are somewhat thicker than the capillaries, and form sometimes straight, sometimes coiled canals, which are covered on their inner surface with a thin layer of delicate cells.

The cortical substance is made up of innumerable fine, much coiled blood-vessels and urinary tubules.

In many places in the cortical substance the blood-vessels and tubules are in very close union, and form little rounded bodies scarcely visible to the naked eye, Malpighian* bodies, in which excretion of urine goes on.

uric acid does not take place in a normal way; these diseases, therefore, are especially dangerous.

Inflammations of the kidney frequently follow chills, wetting, and quick cooling of the loins, also as a sequela of scarlet fever, cholera, &c. In most inflammations of the kidney the urine contains albumen. In summer the excretion of superfluous water takes place especially through the sweat-glands, and activity of the kidney is diminished; the contrary is the case in winter.

* Malpighi, a celebrated anatomist and physician in the seventeenth century.

Showing Skull divided perpendicularly through the Centre.

1. Skin.
2. Tendinous covering.
3. Cranial bones.
4. Superior longitudinal sinus.
5. Cerebrum.
6. Cerebellum.
7. Arbor vitæ.
8. Corpus callosum.
9. Optic chiasma.
10. Corpora albicantia.
11. Pituitary body.
12. Optic thalamus.
13. Pons varolii.
14. Medulla oblongata.
15. Spinal cord.
16. Frontal sinus.
17. Spreading out of the olfactory nerve on the walls of the nasal cavity.
18. Perpendicular lamina of the ethmoid bone.
19. Vomer.
20. Cartilaginous septum of the noso.
21. Eustachian tube.
22. Uvula.
23. Cavity of the mouth.
24. Tongue.
25. Incisor teeth.
26. Hard palate.
27. Inferior maxillary bone, or lower jaw.
28. Hyoid bone.
29. Epiglottis.
30. Cartilages of the larynx.
31. Trachea.
32. Rima glottidis.
33. Œsophagus.
34. Ligamentum nuchæ.
35. Spinous processes of cervical vertebræ.
36. Interspinous muscles.
37. Bodies of the vertebræ.
38. Intervertebral cartilages.
39. Sphenoid bone.
40. Sphenoidal sinus.
41. Sutures of the cranial bones.

The urine is next received into the coiled tubules of the cortex, and is then conducted through the straight tubules of the pyramids into the pelvis of the kidney, a membranous, funnel-shaped sac, placed on the concave side of the kidney. The urine flows drop by drop from the apex of the pyramids into the pelvis, and passes hence through the ureters (two membranous tubes about the size of a quill), downwards into the urinary bladder (III. 37). This forms a pear-shaped bladder placed in the true pelvis, which consists of an outer connective tissue, a middle muscular, and an inner mucous coat.*

Pelvis of the kidney.

Ureters.

Bladder.

The supra-renal body is found at the upper border of each kidney; it is a flat gland, about 2 to 2·5 cms. in height, 4 to 5 cms. broad, and only a few millimetres thick; it has no excretory duct, it consists of medullary and cortical substance. The function of the supra-renal body is unknown.

Supra renal bodies.

FOURTH PART.

THE NERVOUS SYSTEM AND ORGANS OF SENSE.

Brain, spinal cord, nerves, organs of special sense.

Plate IV.

Preliminary Remarks.

The whole nervous system is divided into central and peripheral parts; they are both in intimate union with each other.

The brain and spinal cord are considered the central parts, the cerebral and spinal nerves and the ganglia and sympathetic nerves form the peripheral parts.

Kinds of nerves.

The cerebral and spinal nerves are partly nerves of sensation and partly of movement. The former, like telegraph wires, convey outside impressions (pain, light, sound, &c.) to the brain (centripetal), while the latter are the channels in which the impulses generated in the brain are conveyed to the organs of movement of the body, the muscles (centrifugal stimuli).

* Small hard masses called renal or urinary calculi are frequently deposited in the kidneys and bladder from the urine, just as gall-stones are deposited from the bile.

These stimuli always go in one direction. This part of the nervous system is called the voluntary nervous system.

The ganglia, or sympathetic nerves, are chiefly distributed in certain organs, which are not subject to the control of our will, for example, the stomach, intestines, &c. They form the involuntary nervous system; this is united with the voluntary system by numerous nerve fibres.

Nerve substance.

The nerve substance, which forms the chief mass of the brain, spinal cord, and nerves, is a soft, white or grey-red substance, very rich in blood-vessels.

The white substance is chiefly found in the interior of the brain, in the outer layers of the spinal cord, and in the peripheral nerves. The grey substance is found in the outer part of the brain, the central part of the spinal cord, and the sympathetic nerves. The grey substance is richer in blood vessels than the white, and there is less of it.

By microscopic examination there can be recognised in the nerve substance—

Fine microscopic tubes or fibres (nerve fibres),

And delicate various-shaped cells (nerves or ganglion cells).

By chemical examination it is found that nerve substance consists mainly of albumen and phosphorus, containing fat.

Nerve fibres.

The nerve fibres which do not have a similar diameter in all nerves have an identical structure. They never branch, they never blend with each other, but they run as uninterrupted threads from the brain to the peripheral parts of the body or *vice versâ*. Each separate nerve fibre is surrounded by a membranous covering which separates the individual fibres from each other; several of such nerve fibres are united by fine connective tissue-covering to form bundles, which are surrounded by a somewhat stronger common sheath. A certain number of such bundles go as a rule to form a nerve, which can be seen as a white cord between the muscles, under the skin, &c. The outermost covering of the whole nerve is called the nerve sheath.

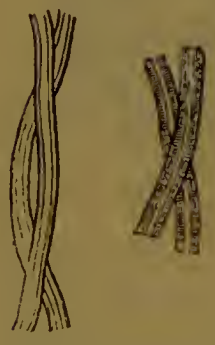


Fig. 40. Nerve fibres, with axis cylinders and medulla (× 700).

In the brain the nerve fibres are in close contact without coverings, but are all protected by the membranes which cover the brain, as will be seen later.

The nerve or ganglion cells are chiefly found in the grey substance of the brain and spinal cord, and in the region of the sympathetic nerve system.*

* During life electrical phenomena can be observed in the nerves and muscles; these are manifest in different ways, according as the nerve is active or not.

I.—The Brain and Spinal Cord.

(The Central Organs of the Nervous System.)

View obtained when the skull is divided perpendicularly through the centre.

A. Cerebrum, or brain proper.
B. Cerebellum, or little brain.
C. Spinal cord.
1. Olfactory (nerve of smell).
2. Optic (nerve of sight).
3. Motor oculi.
4. Pathetic nerve.
5. Trifacial (trigeminus) nerve.
   (*a*) Small root.
   (*b*) Large root.
6. Abducens.
7. Facial.
8. Auditory.
9. Glosso-pharyngeal.
10. Vagus or pneumogastric.
11. Spinal accessory.
12. Hypo-glossal.
13. Corpora albicantia.
14. Infundibulum.
15. Pons varolii.
16. Medulla oblongata.
17. Anterior lobes of the brain.
18. Middle lobes of the brain.
19. Posterior lobes of the brain.
20. Internal carotid arteries.
21. Basilar artery.
22. Vertebral arteries.
23. Spinal nerves.
   (*a*) Anterior roots (motor roots).
   (*b*) Posterior roots (sensory roots).
24. Ganglia of the spinal nerves attached to posterior roots.
25. Cone of spinal cord (where spinal cord becomes smaller).
26. Filum terminale (slender filament in which spinal cord ends).
27. Cauda equina (roots of origin of the lowest spinal nerves).
28. Dura mater (protecting sheath of spinal cord).
29. Ligamentum denticulatum (band dividing anterior from posterior root of spinal nerve).

Fig. 41.

I. The Brain.

The brain is an organ consisting of nerve tissue and blood vessels which lies within the skull, and is the seat of all the higher senses and mental activities. All intellectual functions, all sensory impressions, are accomplished in the brain; also the impulses to all voluntary movements start from the brain. It has a flat base, which rests on the base of the skull, and an upper arched surface. The length of the brain from before backwards amounts in adults to about 14 cms., the breadth about 12 cms., the thickness is about 12 cms., and the weight varies between 1·5 to 2·0 kilos.*

The whole brain is divided into the cerebrum, or large brain, and the cerebellum, or small brain, and the middle brain.

* The brain of women is about 50 to 60 grammes lighter than that of men; the weight of the brain of animals is in relation to the weight of the whole body much less than that of the human brain—the latter amounts to $\frac{1}{45}$ to $\frac{1}{50}$. The weight of the horse's brain is only about 750 grammes. Disturbances of the mental activity, if unaccompanied for a longer time by fever, are called mental diseases. Temporary disturbances, such as are seen in febrile diseases, &c., are called delirium.

The Large Brain (IV. 5.) fills the anterior and upper part of the cranium, and forms about seven-eighths of the whole brain substance.

It is divided into two lateral halves by a deep longitudinal fissure running from before backwards, and 2·0 to 2·5 cms. deep. Each half is called a hemisphere.

Each of the hemispheres is further divided into an anterior (IV. 17), middle (IV. 18), and posterior part (IV. 19), which are separated from each other by depressions at the base. These parts are called lobes of the brain. As there are in the cerebrum six divisions there must be two anterior, two middle, and two posterior lobes.

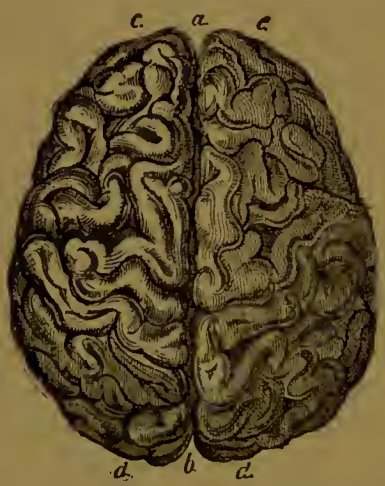


Fig. 42. Upper surface of the Brain, seen from above.

a.b. Great longitudinal fissure dividing the brain into right and left hemispheres. *c.c.* Frontal lobes of the cerebrum. *dd.* Occipital lobes.

The surface of the cerebrum shows irregular convolutions,* in appearance like intestines; they are separated from each other by furrows 1·2 to 2·3 cms. deep. Each of these furrows has its special designation (Fig. 42).

The cerebrum consists in its inner parts of white nerve substance (medullary substance); in the periphery, including the convolutions, there is a layer of grey nerve substance three to four millimetres thick, the cortex. The white substance is throughout its whole extent made up almost entirely of nerve fibres; the grey substance, of round or stellate cells (ganglia or brain cells), which are connected partly with each other, partly with the fibres of white substance. In the interior of the cerebrum there are four cavities which communicate with one another. One lies in each lateral hemisphere, two others, unpaired, lie in the middle line.†

* In animals, especially the lower ones, these convolutions are few in number or entirely absent. The more intelligent a being is the more numerous and complicated are the convolutions.

† If fluid collects in these cavities in disease, the disease is called "water on the brain," or hydrocephalus. It occurs most frequently among children. The separate parts of the brain have been endowed by anatomists with special names. It would lead us too far if we were to consider here the fine anatomical relations. It is only necessary to mention that the individual parts are either symmetrically placed in pairs in the two hemispheres, or lie unpaired in the middle line. The base of the brain has an especially complicated structure. At the base lie the crura cerebri, the pons varolii, the grey tubercle, the chiasma, the infundibulum, the twelve pairs of cerebral nerves, which go partly to the sense organs, partly to the muscles of the face, and partly supply sensory nerves to the skin of the face, glands, &c. In the interior of the cerebrum lies the corpus callosum, the septum lucidum, the fornix, the optic thalami and the corpora striata.

The cerebrum is covered by three membranes, lying one above the other.

Membranes of the brain.

The outermost, strongest membrane, lying next to the skull, is the dura mater. It covers the whole inner surface of the skull and the spinal canal. It has a blue-white colour, and forms in the middle line of the skull a sickle-shaped fold, running from before backwards, which lies in the above-mentioned longitudinal fissure between the two hemispheres, and is called the Falx cerebri.

This membrane also forms in the posterior and lower part of the skull a transverse fold running from side to side, the Tentorium, which separates the cerebrum from the cerebellum.

In the dura mater several arterial vessels run. There are also present specially wide canals called sinuses, in which the venous blood returning from the brain collects and passes through openings in the base of the skull into the large veins of the neck (the jugular veins), thence to the heart.

The middle membrane is called the arachnoid. It belongs to the serous membranes, and is as such similar to the peritoneum and the pleura.

It is thin, delicate, and consists of two layers in close apposition, of which the outer one is in contact with the inner surface of the dura mater, the inner one with the outer surface of the pia mater. The arachnoid secretes a certain quantity of fluid which moistens and keeps the surfaces of the membranes which are in contact with each other supple. It does not penetrate between the convolutions.

Like the dura mater, it also extends into the spinal canal and forms with it a protective sheath round the spinal cord.

The pia mater lies immediately upon the brain substance, and penetrates between the convolutions and into the cavities of the brain. It is extremely thin, delicate, rich in blood vessels, and on that account very prone to inflammation.*

The brain is supplied with blood by four large arteries (IV. 20 and 21) —the two internal carotid and the two vertebral arteries.†

* In children, the brain and pia mater are often inflamed. The consequences are convulsions, paralysis, vomiting, and loss of consciousness. In concussion of the brain similar phenomena arise, also in hæmorrhages into the brain.

† In old age the walls of these arteries become calcified. They are in consequence brittle and easily torn. When they are torn the blood escapes into the brain substance surrounding the vessels, ploughing it up. According to the quantity of the blood poured out and the part of the brain destroyed, life is either immediately extinguished, or those parts are paralysed or impaired in function whose nerves arise in the injured part of the brain. The man will, for instance, become suddenly blind or lose his speech, or an arm or leg, &c., will be paralysed according as the hæmorrhage has its seat in the centres of vision, speech, or movement for the arm or leg. These sudden attacks are called fits of apoplexy.

The blood is carried back, as already mentioned, by the two jugular veins.

Lympathic vessels have not yet been found in the brain.

The Cerebellum (IV. B.).

The Cerebellum, or small brain, lies in the posterior lower part of the cranial cavity, covered by the posterior lobes of the cerebrum, and separated for the most part from this by the already mentioned transverse fold of the dura mater, the tentorium. It presents a three-sided body, somewhat higher in front, somewhat broader and lower behind. Its breadth is about 7 to 9 cms., its length about 5 cms., its height 3·5 to 4·5 cms., and its weight about $\frac{1}{8}$ of the whole brain mass.

The cerebellum has two lateral halves or hemispheres, which are divided by several deep horizontal notches into numerous lamellæ lying one over the other.

As in the cerebrum, the grey substance occupies the periphery, the white substance the medulla, which is divided by the notches into numerous lobules or lamellæ; in section it presents a tree-like appearance, and is called the arbor vitæ.*

The Middle Brain.

Those parts of the brain which unite the cerebrum, the cerebellum and the spinal cord together, form the middle brain. These lie chiefly at the base of the brain, they consist of the medulla oblongata, the pons varolii, and the corpora quadrigemina. The medulla oblongata is the uppermost somewhat enlarged part of the spinal cord (IV. 16); it lies on the under surface of the cerebellum, and is attached to it by two strong bands.

The pons varolii (IV. 15), is a thick, transverse band of nerve substance at the anterior upper end of the medulla, and is connected by thick bands of nerve partly with the medulla, partly with the cerebrum and cerebellum; the corpora quadrigemina lie in the interior of the brain between the cerebrum and cerebellum.†

* In the middle line of the cerebellum lie the upper and lower vermiform processes, the amygdala, the flocculus, the pyramid, &c.

† As to the functions of the individual parts of the brain, these are only partly known to us. We know for example that the hemispheres of the cerebrum, especially the grey substances, are the organs of the higher mental activities, that in these structures perception, will, thought, consciousness &c., reside. We do not completely know, however, how the mental activities arise. The nourishment of the brain takes place chiefly during sleep; activity of the brain during sleep expresses itself in dreams.

II. The Spinal Cord, or Marrow.

The spinal marrow resembles a long cord, consisting of nerve fibres and nerve or ganglion cells, somewhat compressed from before backwards, about 6 to 8 millimetres in diameter. It lies in the spinal canal, and extends from the occipital foramen to the second lumbar vertebra; it is covered by three membranes which correspond to the above-mentioned membranes of the brain, and are to be regarded as continuations of them.

The spinal cord, which is continuous with the brain, is made up of countless motor and sensory nerve fibres. In the anterior part of the cord lie the motor nerves, the sensory nerves being in the posterior part.

On both sides, at different heights, the 31 pairs of nerves pass out from the spinal cord; they consist of an anterior and posterior root (IV. 23, a, b), the former of which contains motor nerves, the latter sensory nerves, which supply the different parts of the body with nerves of movement and sensation.

The posterior root of the spinal nerve swells, after it has penetrated the membranes of the spinal cord, into a ganglion the size of a small pea (IV. 24).

The spinal cord itself is made up, in its central parts, of grey matter, in its peripheral parts, of white matter, an arrangement unlike that of the brain. It has an anterior and posterior longitudinal fold by which it is separated into two lateral halves, like the brain.

The spinal cord ends below in a short conical body (IV. 25), from which a strong cord (filum terminale), (IV. 26), goes down to the coccyx, where it is firmly attached.

Cauda equina.

The nerves rising from the under part of the cord, and running to the lower extremities, have very long roots, and form a very sharp angle with the cord. As they are united in great numbers in the lower part of the spinal canal, they form a bundle of separate nerves, which are called the cauda equina.

The spinal cord is not uniformly thick throughout; it has a cervical and lumbar swelling corresponding to the seat of origin of nerves of the upper and lower extremities.*

The cerebellum unites different movements to one end. By the medulla, the respiratory mechanism is regulated. All parts of the brain are not sensitive. The cerebellum and the different parts of the cerebrum, especially of the cortex, can receive deep wounds without the injury giving rise to pain.

* Diseases of the spinal cord frequently bring about paralysis and loss of sensation in the arms and legs, and often cause great pain and convulsive contractions of the muscles.

II.—The Nerves.

The nerves, which are made up of individual fibres, are divided into (1) brain and spinal nerves, (2) the sympathetic nerves or ganglia.

I.—The Brain and Spinal Nerves.

These are either sensory or motor nerves; they arise in the brain (cerebral nerves), or in the spinal cord (spinal nerves).

The farther they go from their central points of origin, the more nerve fibres are given off from the nerve cords, the more they branch, without, however, their individual fibrils dividing or uniting.

The direction of impulses in the different fibres is, as already mentioned, different in different kinds of nerves.

Motor and sensory nerves.

In the motor nerves, it takes place from the brain to the muscles (from centre to periphery—centrifugal). In the sensory nerves from the skin &c., to the brain (from periphery to centre—centripetal).

The motor nerves are the channels in which impulses of the mind are conducted to the voluntary muscles, and these stimulated to contraction. In the sensory nerves on the other hand, impressions received from without—perceptions—and stimuli of all kinds, are conducted to the brain.*

As a rule, the large nerves contain mixed fibres—that is to say motor and sensory fibres.

Only very few organs and parts of the body possess no nerves, for instance, nails, hair, cuticle, cartilage, &c. Also many of the internal organs (lungs, spleen, liver, &c.,) possess either very few or no sensory nerves. In the central organs of the nervous system the nerve fibres are connected with nerve cells. The peripheral threads terminate mostly in complicated end organs, as for example nerves of the organs of sense, eye, ear, skin, &c. The kind of peripheral termination of many nerves is not yet completely known.

* If, for example, I touch a hot object with my finger, the pain thus produced is conveyed by the sensory nerves to the brain. The motor nerves immediately receive the command to excite the muscles concerned to contraction, and the finger which received the pain is withdrawn.

All these processes, however, are the work of a moment.

If a motor nerve is cut across or destroyed, paralysis is produced, if it is irritated, contraction ensues in the muscles. Irritation of a sensory nerve causes pain, its section or destruction causes loss of sensation, numbness, &c.

The impressions received by one nerve often radiate into other nerves; in this way different collateral movements and sensations are explained. For instance, sneezing on looking at the sun, throbbing of the heart in anxiety, fear &c.

The cerebral nerves appear at the base of the brain and pass out through the various openings in the base of the skull to the organs of special sense, to the various parts and organs (muscles, skin, &c.), of the face ; partly, also, of the neck and chest.*

The spinal nerves, 31 pairs, leave both sides of the spinal cord as already mentioned. They arise by two roots, and supply the skin as well as the muscles of the body and limbs with sensation and motion.

The large nerve trunks, after they leave the brain and spinal cord, run deeply (protected by muscles) as more or less thick, white, rounded strands, which send out branches on all sides, and finally break up into countless threads.

II. The Sympathetic Nerves. (The Ganglionic System.)

The sympathetic nerves form a nervous system for the most part complete in itself, and partly independent of the cerebral and spinal nerves, but they exchange numerous fibres with the latter.

Ganglia.

The digestive organs, and those accessory to digestion, the glands &c., are chiefly supplied by this nervous system, and give rise to an activity which is independent of our wills. The processes of nutrition and tissue change are further regulated by it. There are present in it a large number of ganglia, or masses of nerve tissue which consist for the greater part of separate nerve fibres and nerve or ganglion cells. These nerve ganglia reach the size of a pea or small bean ; at the same time they form the central organ of the sympathetic system, just as the brain and spinal cord do for sensation and voluntary movements. They are scattered generally over the body especially in the thoracic and abdominal cavities. Innumerable nerve fibres start from them, and form a net-like covering around the different organs (stomach, intestines, liver, blood-vessels, &c.) The largest nerve plexus is the solar plexus ; it lies behind the stomach.

* The twelve pairs of cranial nerves are the following :—

The olfactory (IV. 1), (distributed to the nasal mucous membrane) ; the optic (IV. 2) ; the oculo motor (IV. 3) ; the trochlearis (IV. 4) ; the abducens (IV. 6) ; (the last three supply the nerves of the eye) ; the trigeminal (IV. 5), (contains nerves of movement, the muscles of mastication, and supplies the skin of the face and forehead with sensation) ; the facial (IV. 7), (moves most of the facial muscles) ; the auditory (IV. 8) ; the gustatory (IV. 9), (ends in the mucous membrane of the tongue, and the pharyngeal muscles) ; the pneumo-gastric (IV. 10), (sends fine fibres to the organs of voice and breathing, to the stomach, &c.) ; the spinal accessory (IV. 11), (goes to the different muscles of the back); the hypoglossal (IV. 12), (moves the tongue and laryngeal muscles).

The spinal nerves, which come from the spinal cord, are named according to the place at which they leave the spinal canal ; they are divided into cervical, dorsal, lumbar, sacral, and coccygeal nerves.

A row of such ganglia, all connected, lies on each side of the vertebral column. It consists of about 25 separate ganglia, which are connected by large numbers of fibres with the voluntary nervous system, with each other, and with neighbouring ganglia.

III.—The Organs of Sense.

The organs of sense are mechanisms by whose means certain conditions and appearances of the outer world are received and conducted to the brain. If, for example, a ray of light, that is to say a number of vibrations of ether,* enters the eye, or if a tone, that is to say a number of vibrations of air, reaches the ear, the end organs of the visual and hearing apparatus are stimulated, and certain changes and movements or vibrations are excited in them.

These are transferred to the finest parts (molecules) of the nerves of sight and hearing, and produce in them certain molecular movements which are again transferred to the brain. The way in which this is accomplished is not yet known.

The senses are generally supposed to be five in number: touch, taste, smell, hearing, sight. The organs supplied by these five senses are the skin, tongue, nose, ear, and eye. Physiology considers that there are other senses, some of which we shall mention later.

I. Touch (Feeling). The Skin with the Touch Corpuscles.

The skin, as the chief seat of the sense of touch, has been already described (page 26, &c.). We repeat here that on the outermost surface of the corium large numbers of elevations (touch papillæ), are found. Many of them contain touch corpuscles; these are the end organs of the sensory nerves, and consist of an oval bladder about one-tenth of a millimetre long, surrounded with elastic fibres, and containing nuclei. The closer the skin is set with touch corpuscles, the finer is the sense of touch, as on the finger-tips, inner surface of the hand, tip of the tongue, lips, &c. By the sense of touch, impressions about the form and structure of objects which we feel are conveyed to the brain.

Fig. 43. Papilla of skin with touch corpuscle.
a. Nerve branch entering. *b*. Ending of a nerve fibre. *c*. Nuclei.

If the touch corpuscles are too much stimulated, that is, too strongly pressed or hit, painful impressions arise. Round and smooth bodies feel more pleasant than sharp and angular ones.

* By ether is understood an imponderable, invisible, elastic material, which fills the spaces between the most minute parts of the body.

The heat sense can be further distinguished, its peripheral end organs must also lie in the skin. Their nature is still unknown. There are certain nerves which convey the stimulus produced by cold or heat on the outer skin to the brain, and hence to our consciousness. The nerves which conduct cold and warm impressions to the brain are quite distinct from the touch or sensory nerves, because, in man, touch and sensation may be completely paralysed, while the sense of temperature is very well maintained in the paralysed limbs, and indeed is sometimes abnormally raised.

By constant repetition of the stimulus which cold or heat exercises on the skin the delicacy of the temperature sense is blunted.

It exists most keenly in the tip of the tongue, the lips, eyelids, neck, &c. Finally, there is also a muscular sense; this teaches us the form, shape, and weight of objects which we can touch and lift. By it we receive an impression concerning the direction in which pressure or a blow approaches the organ of touch. We can judge of the distance of two points from each other on the skin. If, for instance, we touch dice, we receive from the position and movements of the fingers when we touch the edges (in other words, from the exertion which the muscle must undergo), an opinion about the edges and size of the dice. Also by the muscular exertion which it is necessary to make when we press on the surface of a body, or when we take it and balance it in our hand, we come to a conclusion about its consistence and weight. If we take pen in hand and write, it is especially the muscular sense by which we measure the separate exertions which the different muscles must put forth. It is obvious that sight and touch help and supplement the muscular sense. How much practice is required to give the muscular sense its necessary keenness is seen in the awkwardness of the left hand if one tries to write or draw with it: originally both hands were equally adapted. How far it can be carried by practice we see in the enormous hand and finger dexterity of piano players. It is chiefly the muscular sense in them which is brought to such great perfection.

II. The Sense of Taste—the Tongue.

The most important organ for taste is the tongue; the hard and soft palate also, and the inner surface of the cheeks are sensitive to taste impressions. The tongue is a very mobile organ consisting of muscle substance; it is placed on the floor of the mouth, and serves at once the purposes of speaking, chewing, and swallowing. The tongue muscles arise partly from the hyoid bone, partly from the inner surface of the lower jaw. They bring about the extremely varied movements and changes in the shape of the tongue.

It is covered with mucous membrane, beneath which countless fine papillæ of different sorts are found, which are partly organs of touch, like the papillæ of the skin, partly organs of taste, as the nerves of taste end in them.

Fig. 44. Tongue.

a.a. Horns of hyoid bone. *b.* Epiglottis. *c.* Circumvallate taste papillæ. *d.* Filiform papillæ. *e.* Dorsum of tongue. *f.* Tip of tongue. *g.* Root of tongue with lens-shaped elevations.

The end organs of the nerves of taste are microscopic structures like little buttons or onions, which are present in great numbers in and near the papillæ. On the under surface of the tongue there is a vertical fold which unites the tongue with the floor of the mouth, and is called the frenum linguæ.*

The tongue has the following parts :—

An anterior part, the tip, a very sensitive organ of touch.

An upper part, the back of the tongue.

A posterior part, the root of the tongue.

When foods, and especially soluble substances, touch the ends and end organs of the nerves of taste, the impression is conveyed to the brain and recognised.†

The glosso-pharyngeal nerve is the peculiar nerve of taste. The nerves of touch and sensation of the tongue arise from the trigeminal nerve and the motor nerves from the hypoglossal (page 65).

The sense of taste is most strongly developed at the back of the tongue, where the large circumvallate papillæ are found ; less strong on the edges of the tongue, and on the soft palate, it is entirely absent on the under surface of the tongue.

III. The Sense of Smell—the Nose.

The nose is formed, in its anterior part, of several cartilaginous plates ; behind them are the nasal processes of the upper jaw and the nasal bones (I. 8).

* The tongue is sometimes joined by mucous membrane to the floor of the mouth to a too great extent. The frenum must be cut through in these cases, and the tongue set free.

† Only those substances which are soluble in water, or in the saliva and mucus which are found in the mouth, can be recognised by taste. Insoluble substances have no taste.

When the cells of the mucous membrane of the upper surface of the tongue are cast off in greater number and more mucus is secreted than usual, the tongue is called "furred." With a dry or furred tongue, taste is impaired.

The skin is stretched over this cartilaginous and bony framework. In the interior the nose is divided into two lateral cavities by a septum, which is cartilaginous in front, and bony behind—the vomer and the vertical plate of the ethmoid. The nasal cavities communicate by two openings with the throat—the most posterior part of the mouth. The air gains entrance in front through the nostrils; the nasal cavities have, like the mouth, an active part in the formation of voice and speech. The air is also warmed in them before its entrance into the lungs. On each side of the lateral wall of the nasal cavity are three much-curved turbinated bones lying one above the other.*

The wall of the nasal cavity is covered with mucous membrane.†

In the part of the mucous membrane which covers the upper part of the vertical septum of the nose and the upper turbinated bone, the branches of the nerves of smell run. They reach the nasal cavity from the brain by fine holes in the ethmoid bone.‡

The nerves of sensation of the nose are present mainly in the anterior and lower parts; by means of them we are conscious of irritation, tickling, &c., in the nose.

The finest fibres of the nerves of smell, like those of all sensory organs, have certain end organs,§ by means of which the irritation which is generally produced by odorous substances is communicated to the nerve fibres and conveyed to the brain.

In order to be able to recognise substances by smell, they must be volatile; in other words, they must exist in a gaseous state. If the nasal mucous membrane is dry or inflamed, or covered with mucus, smell is blunted.

Several cavities are in connection with the nasal cavity—those in the upper jaw, the frontal and sphenoidal sinuses; the nasal or lacrimal duct also enters it by a canal running down from the orbit.

* In animals, especially those which have a very sharp sense of smell, as the dog, &c., these bones form an unusually complicated structure. Their surface presents numerous little folds of bone. The surface on which the nerves of smell are spread is therefore enlarged. The shape of the nose varies much among different races of men.

† Inflammation of the nasal mucous membranes is called "cold in the head." This often extends to the mouth and larynx, also to the mucous membrane of the eustachian tubes, whence the frequency of deafness in cold in the head. Growths from the nasal and mucous membranes are called polypi.

‡ The nerves of smell, entering the nose from the brain through the ethmoid bone, close the holes which exist in the ethmoid for this purpose so tightly that the entrance of dust, living animals, worms, &c., or other fine substances, from the nose to the brain, is not possible.

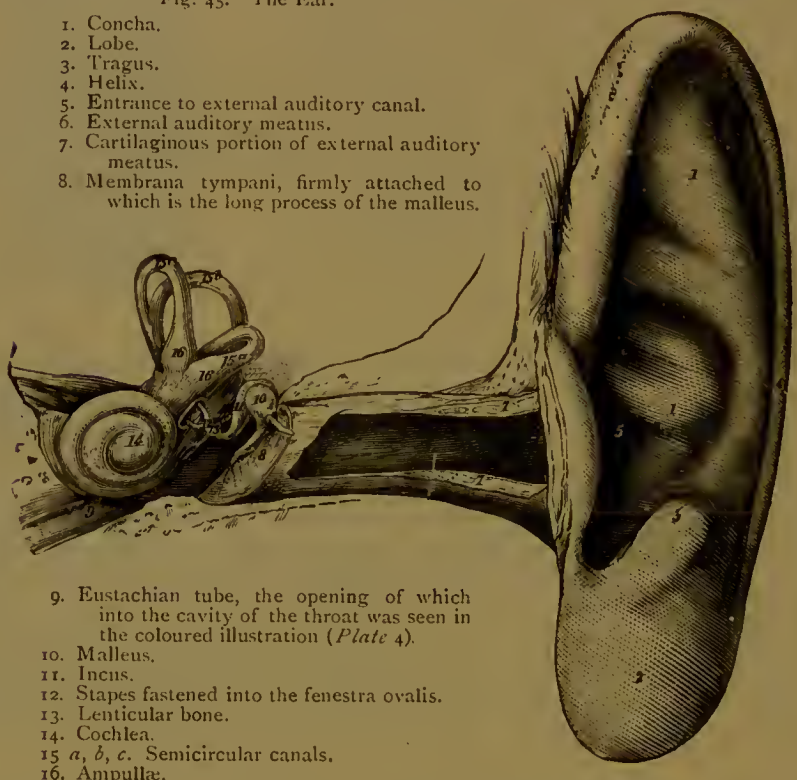
§ In the nerves of smell they are like cylindrical cells provided with fine threads.

IV. The Sense of Hearing—the Ear (Plate 4).

The organ of hearing, which serves for the reception of sounds, and which communicates the impressions aroused by the sound waves (vibrations of the air) to the brain, is divided into an outer and inner part. To the outer part belong the auricle, and the external auditory canal, to the inner part the tympanic cavity, with the tympanic membrane, the ossicles, and the labyrinth.

Fig. 45. The Ear.

1. Concha.
2. Lobe.
3. Tragus.
4. Helix.
5. Entrance to external auditory canal.
6. External auditory meatus.
7. Cartilaginous portion of external auditory meatus.
8. Membrana tympani, firmly attached to which is the long process of the malleus.



9. Eustachian tube, the opening of which into the cavity of the throat was seen in the coloured illustration (*Plate* 4).
10. Malleus.
11. Incus.
12. Stapes fastened into the fenestra ovalis.
13. Lenticular bone.
14. Cochlea.
15 *a*, *b*, *c*. Semicircular canals.
16. Ampullæ.

The auricle.

A mussel-shaped, rounded plate of cartilage forms the ground substance of the outer ear, and has many elevations* and depressions, this receives and intensifies the sound. The skin, very rich in nerves, is tightly stretched over this plate of cartilage; the cartilage extends inwards to the auditory passage, and downwards to the lobe of the ear at the lower part of the auricle.

The lobule of the ear is free from cartilage, and contains a certain amount of fat. Where the external ear is attached to the skull there

* The elevations form the helix, the anti-helix, the tragus, the anti-tragus, and the lobule. The larger the ear, the more it stands out from the head, the deeper its auricle, and the more adapted it is for hearing.

are several thin bands of muscle by means of which the ear can be slightly moved backwards and forwards.*

External auditory canal.

The external auditory canal runs horizontally from without inwards, somewhat curved forwards. It is about 2·2 centimetres long and $\frac{1}{2}$ centimetre wide. The anterior part of the outer canal is cartilaginous, the posterior part has bony walls formed of the petrous bone.

The external auditory canal is lined with the outer skin, which is very thin, and possesses numerous little hairs and glands; the former prevent the entrance of foreign bodies, the latter secrete wax.†

The drum.

The auditory canal is closed transversely at its inner part by the drum of the ear or tympanic membrane.

This is a transparent, thin, elastic, blue-red membrane, which runs obliquely from above downwards, and inwards. It can be rendered tense and slackened by little muscles.‡

Tympanum.

Behind the tympanic membrane lies the tympanic cavity, covered with mucous membrane, with the ossicles and the Eustachian tube. These parts are also called the middle ear.

The tympanic cavity is a hollow space situated in the petrous bone, and surrounded by bony walls, it is only a few millimetres in diameter; the ear-trumpet or Eustachian tube enters it from below, and forms an open channel between the throat and the tympanic cavity.§

Fig. 46. The Ossicles of the Ear.

a. Stapes. *b*. Incus. *c*. Its short process. *d*. Its long process with *e*. lenticular process. *f*. Malleus. *g*. Handle of the malleus. *h*. Processus gracilis of the malleus.

The ossicles.

The auditory ossicles are very small bones, only a few millimetres in size, they are called the malleus, the incus, and stapes.

The malleus, which presents several thin processes, the longest of which is attached to the tympanic membrane, lies furthest forwards and outwards.

* In many animals, as in the horse, &c., these muscles are much more developed than in man.

† If the wax collects in the ear to any extent deafness arises.

‡ The tympanic membrane can be easily ruptured by injury, such as a blow on the ear. In this way permanent deafness may be brought about. If it is perforated, air, tobacco-smoke, &c., can be forced through the external auditory canal outwards. In later years the tympanic membrane becomes thickened and opaque, it loses its elasticity, and causes deafness.

§ Eustachius, or Eustachio, was a celebrated anatomist in the Middle Ages.

Blockage of the Eustachian tubes during a cold causes noises in the ears, deafness, &c.; the same thing happens when the opening is covered by an enlarged tonsil.

The incus is united to the malleus by a joint, and presents two thin processes, one of which is attached to the stapes, a small bone which has the shape of a stirrup, and whose base is somewhat movably attached to an oval opening in the inner wall of the tympanic cavity.

These two bones form a system of levers; as soon as the tympanic membrane is thrown into vibration the three ossicles are set in movement, and the base of the stapes is slightly pressed into, or withdrawn from its opening.

The labyrinth.

This opening, called the fenestra ovalis, opens into the vestibule, a very small cavity, about three millimetres in diameter, situated in the interior of the petrous bone, and formed of bony walls. It is filled with fluid or lymph. Extending from this forwards is the cochlea, a canal curved somewhat like a snail-shell. Extending backwards, upwards, and outwards, lie the three hollow, curved tubes, the semicircular canals (XV., a, b, c, and XVI.).*

In these two last-named organs, the cochlea and semicircular canals, the auditory nerve, with its complicated end organs, is distributed. When a wave of sound moves the tympanic membrane, and with it the ossicles, the vibration is communicated through the fenestra ovalis to the lymph, and so to the endings of the auditory nerve in the semicircular canals and cochlea. The stimulation of these is immediately conducted to the brain, whereby we receive the impression of hearing.†

V. The Sense of Sight—the Eye (Plate 4).

The most important part of a visual organ is the eye placed in the orbit. This resembles a camera obscura. It presents a globular, very

* This space on the inner side of the tympanic cavity, consisting of vestibule, cochlea, and semicircular canals, is called the labyrinth. This forms a system of hidden cavities and passages in the petrous bone. In our plate the separate parts of the labyrinth are shown as cavities surrounded by smooth walls, but in the human body they must be thought of as canals lying in the substance of the bone.

† Sound is also communicated to the tympanic membrane through the bones of the skull; one can hear, for example, the tick of a watch when it is held between the teeth or pressed against the forehead. The tympanic membrane and cochlea are in communication by means of an opening, the fenestra rotunda covered by a thin membrane. As soon as the stapes is driven into the fenestra ovalis by the movement of the tympanic membrane the lymph must escape, and as the labyrinth is formed of bony walls, it can only happen by the membrane covering the fenestra rotunda being bulged out. In this way the vibratory movements of the lymph of the internal ear come to rest.

Deaf mutes are people born deaf; they are dumb, not because they have badly developed organs of speech, but because they do not hear speaking, and cannot, therefore, imitate it or repeat the words. By special instruction deaf mutes can be taught to speak.

beautifully made body, which receives the rays of light coming from luminous objects and conducts them inwards. In the neighbourhood of the eye are several accessory organs which move it, protect it from injury, &c.; among them are counted the muscles of the eye, the cushion of fat in the orbit, the lacrimal glands, the eyelids, and the eyebrows. A circular muscle, the sphincter of the eye, lies in front of the eye under the skin of the lids. Another muscle running from above downwards perpendicularly to the lid, raises the upper eyelid.

Eye muscles.

There are six eye muscles, four straight and two oblique. They cause the different movements of the eye, and arise for the most part at the posterior portion of the orbit, and are attached to the anterior portion of the eye by short tendons.*

The eye muscles, as well as the eye itself, so far as it lies in the orbit, are surrounded by a cushion of fat, which protects it from concussion, keeps it warm, and facilitates the movements of the eye.†

Lacrimal gland.

The lacrimal gland is about the size of a bean, of a yellow-red colour, and is placed in the anterior part of the orbit, just above the outer angle of the eye. It consists of several lobules, each of which has a small excretory duct. These are eight or ten in number, and penetrate the conjunctiva in the neighbourhood of the outer angle. The lacrimal glands secrete the tears, a watery, saline fluid, which flows along the lower lid to the inner angle of the eye, and is taken up by the two *puncta lacrimalia*. The puncta lacrimalia appear as two tiny openings, which are visible in the upper and lower lids, in the immediate neighbourhood of the inner angle of the eye, and form the upper part of the tear canaliculi.

The canaliculi are two small short ducts which conduct the tears to the lacrimal sac.

The lacrimal sac lies between the inner angle of the eye and the nose, limited in front by the skin, behind by the lacrimal bone. A somewhat larger canal leads downwards, and empties itself into the nasal cavity beneath the inferior turbinated bone, the tears secreted by the lacrimal gland at the outer part of the orbit are sucked up at the inner angle of the eye by the puncta lacrimalia, conveyed through the canaliculi into the lacrimal sac, and thence into the nose.‡

* If such a muscle is shortened or remains contracted the eye will be drawn towards that side, producing a squint. By section of the tendon of the affected muscle this fault can be removed.

† In the wasting caused by severe illness this fat disappears, and the eye sinks back into the orbit.

‡ If the tears are secreted in large amounts as in weeping, or if the puncta are blocked, they flow over the edge of the lower eyelid on to the cheek.

The eyelids.

The upper and lower eyelids contain a thin, flat mass of cartilage, in contact, on its outer side with the skin, on its inner side with a mucous membrane called the conjunctiva* of the eye. They are capable of voluntary movement.

The conjunctiva extends from the lids to the anterior part of the eye and covers it. The free edges of the lids, which come into contact, carry on their anterior border a number of fine hairs, the eyelashes,† which, with the eyebrows, placed over the eyes, are intended to protect the eyes from harm (dust, &c.). In the cartilage of the lid there are a number of small, closely-packed glands, whose excretory ducts empty themselves on the borders of the lids, and secrete a greasy substance, which keeps the lid smeared, and usually prevents the overflow of the tears.

At the inner angle of the eye there is a small warty elevation, the caruncle, consisting of glands which secrete sebaceous material.

The eyeball.

The eye has the appearance of a globe whose anterior part, the cornea, is somewhat more strongly curved than the posterior and lateral parts.

The greater part of the eye is concealed in the orbit, and only the anterior part, that covered by the lids, is visible.

The eye consists of three membranes. The outermost one is the sclerotic, which is continued in front into the transparent cornea; the middle membrane is the choroid with the iris; the inner one is the retina.

In the interior of the eye, and filling its cavity, lie the media for refraction of light; close behind the cornea, between it and the iris, lies the anterior chamber (8) filled with the aqueous fluid; behind the iris the crystalline lens (10); and, finally, in the posterior two-thirds of the eye, the vitreous (11).

Membranes of the eye.

The sclerotic (4), the white of the eye, to which the muscles are attached, is of a blue-white colour, and surrounds five-sixths of the whole eye. It is a very strong tendinous membrane, which has on its posterior surface a small round opening for the passage of the optic nerve (15).

The sclerotic, which is covered on its outer surface by conjunctiva (1), which is continued from the inner surface of the lids over the eye, secures for the inner delicate parts of the eye certain protection,

* Catarrh of the nasal mucous membrane can be communicated to the conjunctiva of the eye through the lacrimal sac and canaliculi, and cause catarrh of the conjunctiva.

† Sometimes the lashes have a false direction, they are turned inwards towards the eye, they thereby irritate the conjunctiva and give rise to inflammation. By removal of these falsely placed eyelashes the inflammation can be easily cured.

and at the same time prevents, by its want of transparency, the entrance of rays of light to the interior of the eye.

The cornea (2) forms the anterior sixth of the eye, and forms in section a strongly curved portion of a sphere continuous with the sclerotic. It is completely transparent, and is covered on its anterior surface also by conjunctiva, which is here extremely thin and delicate.*

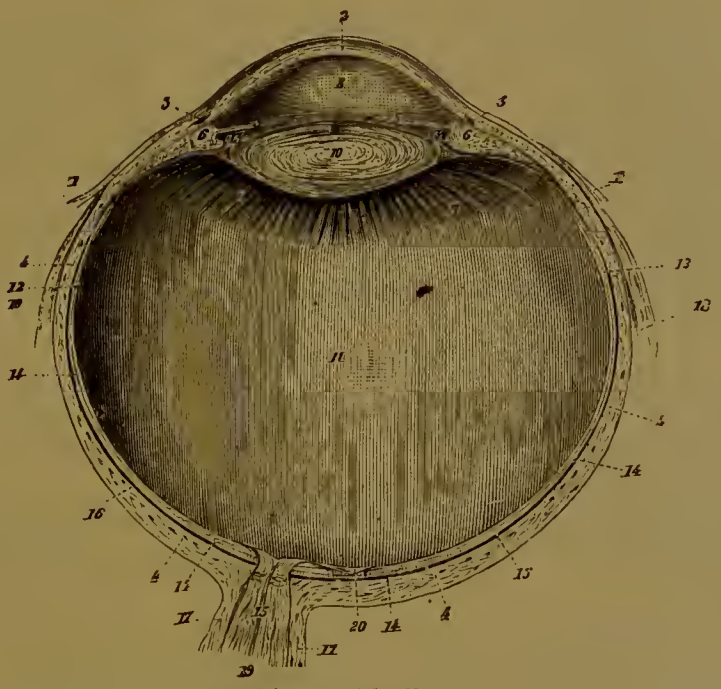


Fig. 47. The Eye.

1. Conjunctiva (outermost covering of eye). 2. Cornea. 3. Canal of Schlemm. 4. Sclerotic. 5. Iris (coloured part of eye). 6. Ciliary muscle. 7. Ciliary body. 8. Anterior chamber of the eye. 9. Pupil. 10. Crystalline lens. 11. Cavity occupied by vitreous humour. 12. Hyaloid, or vitreous membrane. 13. Posterior chamber of the eye. 14. Retina, or nervous tunic. 15. Optic nerve. 16. Choroid tunic. 17. Cellular covering of optic nerve. 18. Eye muscles. 19. Central artery of the retina. 20. Yellow spot.

The whole inner surface of the sclerotic is covered by choroid.†

This membrane is very vascular; its blood vessels form a close network. It is also furnished with innumerable cells, especially on its inner surface, which contain black colouring matter.‡

In front, the choroid is continuous with the iris§ (5). This forms a

* Where the two membranes (cornea and sclerotic) unite, there is a small canal.

† Like the sclerotic, the choroid has on its posterior surface an opening for the passage of the optic nerve.

‡ If the pigment is absent, as, for example, in albinos, in certain white rabbits, &c., the rays of light are again reflected and clear vision, especially in bright daylight, is rendered more difficult.

§ Near the point of union are the ciliary body and the zonule. It would lead us too far if we were to describe the structure of these extremely complicated parts of the eye.

vertical round disc placed behind the cornea, variously coloured in different persons—blue, brown, grey, &c It contains in its centre a circular opening, the pupil (9), through which the rays of light, entering from without through the cornea, reach the interior of the eye.*

Most beasts of prey have a long vertical pupil; animals that chew the cud have a horizontal pupil.

The innermost and most important structure in the eye is the retina. It lines the inner surface of the choroid, is transparent, of a grey-white colour, and consists for the most part of nerve fibres from the optic nerve, with a layer of peculiar end organs communicating with them, which are stimulated by the entrance of light. These are present in greatest numbers at one part of the posterior surface of the eye, the yellow spot (20), which lies in the axis of vision.†

Anteriorly the retina is continuous with the lens through the lens capsule.

Mechanism of refraction.

Immediately behind the cornea, between it and the anterior surface of the lens, in the anterior and posterior chambers of the eye is the aqueous humour. This is completely transparent, and only amounts to a few drops.

By anterior chamber we understand that space which lies between the cornea and iris (8). By posterior the space found between the iris and the lens.

The crystalline lens (10) is to be regarded as the most important of the media of refraction. This is a lens-shaped, completely transparent body, strongly curved on its anterior and posterior surfaces, especially the latter. It is soft on the outside, with a somewhat harder central

* Circular and radially placed muscular fibres are found in the iris; by their contraction or relaxation they produce a narrowing or widening of the pupil, according as more or less light falls into the eye. In darkness the pupil widens in order to allow the light necessary for vision to enter the eye. In brilliant light the pupil narrows in order to modify the powerful light stimulus.

† The end organ consists of a layer of rods or cone-shaped bodies, which can only be recognised by the help of the microscope, and which occupy the outermost or posterior layer of the retina bordering on the choroid. The inner end of the rods or cones communicates with a cell which is joined to a fine nerve fibre; this, after a short course, enters one or more cells, and finally passes into the corresponding nerve fibre of the optic nerve and runs to the brain. The retina consists, then, of an outermost layer of rods or cones, and of several layers of fine fibres, cells, and filaments. In addition, several small arteries and veins, entering the eye by the optic nerve, run in it. The cones of the retina seem to serve for colour perception and the rods for light perception.

Many people are blind for certain colours; they either do not see them at all, or they cannot distinguish them, especially red and green (colour blindness).

part. It lies immediately behind the iris, and is contained in an extremely delicate transparent membrane, the lens capsule.*

The posterior surface of the lens lies in a depression in the front part of the vitreous.

The vitreous (11), the third medium of refraction, fills the posterior two-thirds of the eye, and consists of a completely transparent, colourless, somewhat sticky mass.

The vitreous is contained in a thin transparent membrane, the hyaloid membrane, which is in contact with the retina behind and the lens in front.

When rays of light from a luminous point enter the eye as they pass from the air through the cornea and aqueous they are refracted, that is to say, they do not continue to go in the same straight line, but are bent inwards and made to approach one another. The rays next pass through the crystalline lens, and then through the vitreous; in both of these structures refraction, or bending of the light-rays, takes place. Thus it happens that the rays of light which approach the eye from a luminous point meet again in a point on the retina, so that an exact picture of the object which the light-rays give out is formed on the retina.

The impressions of light on the retina are communicated by the end organs and nerve fibres to the brain, in which the mind receives the impression of physical things and appearances.

When the light-rays proceeding from a luminous point are not again united at a point on the retina, but the meeting point or focus lies either in front of or behind the retina, objects at certain distances cannot be clearly seen. Such eyes are either short or far-sighted.†

* In many animals, especially those which live in water, the lens is very much curved, almost globular.

In old age the lens frequently becomes opaque and causes cataract. The opaque lens can be removed from the eye by operation and the vision restored.

The lens contains neither nerves nor blood vessels.

† The short-sighted eye sees objects near it clearly, distant objects indistinctly. With far-sighted eyes the contrary is the case. In the first case the focus of the light-rays is in front of the retina, and concave spectacles must be used to place the image farther backwards. In far-sighted eyes the focus lies behind the retina; by convex glasses it can be brought forward so that near objects can be fairly sharply seen.

Spectacles are numbered according to the amount of their concavity or convexity. The choice of these numbers, and the determination of the acuteness of vision, must be left to the ophthalmic surgeon.

Human and Animal Parasites.

(See Text, pp. 24 and 25).

Fig. 48. Fresh Trichinæ in Muscle, not yet encapsuled.

Fig. 49. Encapsuled Trichinæ. Capsule partly calcified (× 120).

Fig. 50. Male and Female Intestinal Trichinæ (× 80), the latter containing numerous young.

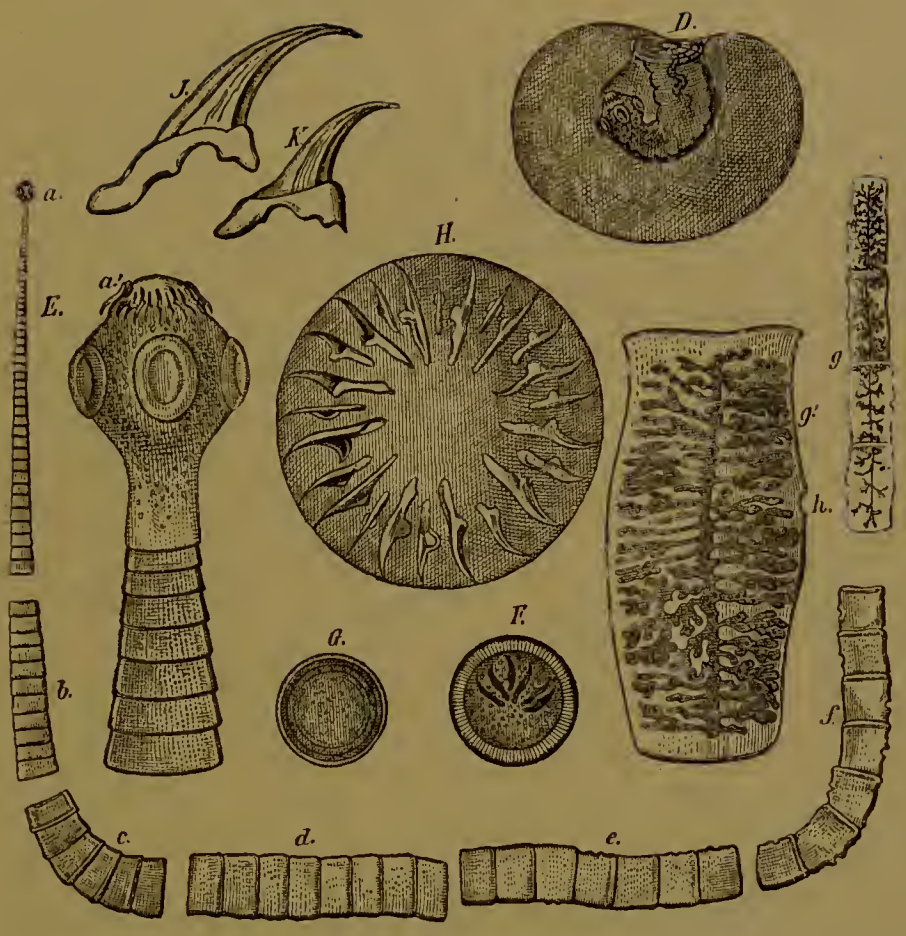


Fig. 51. *D.* Measle of Pig (Cysticercus cellulosæ (× 15).

E. a. Head of the intestinal tænia solium, natural size. *a'.* Head (× 50). *a.-g.* Segments in different stages of development. *g.* Ripe segments. *g'.* (× 4 or 5) ripe segment. *F.* Ripe egg (× 50). *G.* Unripe egg (× 50). *H.* Crown of hooklets from the tænia (× 150). *J.* Larger. *K.* Smaller hooks of the same (× 300). (After Ruprecht.)